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**PUBLICATIONS**  
of the  
**NATIONAL BUREAU OF STANDARDS**  
1901 to June 30, 1947



**CIRCULAR 460**



U. S. DEPARTMENT OF COMMERCE

CHARLES SAWYER, Secretary

NATIONAL BUREAU OF STANDARDS

E. U. CONDON, Director



# PUBLICATIONS

of the

## NATIONAL BUREAU OF STANDARDS

1901 to June 30, 1947

NATIONAL BUREAU OF STANDARDS CIRCULAR 460

Issued August 16, 1948

## FOREWORD

The National Bureau of Standards is the principal agency of the Federal Government for fundamental research in physics, chemistry, and engineering. Its activities include research in electricity, electronics, atomic physics, applied mathematics, mechanics and sound, radio and radio propagation, optics, heat and power, metallurgy, metrology, ordnance, physical chemistry, mineral products, organic and fibrous materials, and building technology.

The Bureau also has custody of the national standards of physical measurement, in terms of which all working standards in research laboratories and industry are calibrated, and conducts research leading to the improvement of these standards, the techniques of measurement, and improved instrumentation. Improved methods of testing materials and equipment are developed, physical constants and properties of materials are determined, and technical processes are investigated.

The results of the Bureau's research, development, and test activities are reported in two types of publications: periodical and nonperiodical. There are three periodicals: the Journal of Research of the National Bureau of Standards, the Technical News Bulletin, and Basic Radio Propagation Predictions.

Mathematical tables, studies and tests of construction materials, safety codes, weights and measures recommendations and information, commodity standards, and miscellaneous compilations of data are reported in the following nonperiodical series: Mathematical Tables, Building Materials and Structures Reports, Circulars, Handbooks, Commercial Standards, Simplified Practice Recommendations, and Miscellaneous Publications.

This Circular presents a complete list of Bureau publications, with brief abstracts for those issued during the period January 1, 1942 to June 30, 1947. Circular C24 and Supplements, listing abstracts of all publications from 1901 to December 31, 1941, are available for those desiring this more complete reference.

E. U. CONDON, *Director.*



# PUBLICATIONS

## of the

# NATIONAL BUREAU OF STANDARDS

## 1901 to June 30, 1947

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## 1. GENERAL INFORMATION

### PURCHASE PROCEDURES

The publications of the Bureau are distributed principally by the Superintendent of Documents, United States Government Printing Office, Washington 25, D. C., who sells them, as long as copies are available, at the prices given in this Circular. Where prices are omitted, the publications are out of print, but may be consulted in reference libraries maintaining sets of Bureau papers.

**How to make remittances.** Remittances for publications for which individual sales or subscription prices are shown should be mailed to:

Superintendent of Documents,  
U. S. Government Printing Office,  
Washington 25, D. C.

The rules of the Superintendent of Documents require that remittances be made in advance, either by coupons sold in sets of 20 for \$1 and good until used, or by check or money order payable to the Superintendent of Documents. Currency, if used, is at sender's risk. Postage stamps, foreign money, and defaced or smooth coins are not acceptable. Postage is not required in the United States, to United States possessions, and to countries extending franking privileges. For mailing to other countries, an additional amount of about one-third of the purchase price is required. Remittances from foreign countries should be by international money order payable to the Superintendent of Documents, or by draft on an American bank. The letter symbol with each publication number and the full title of the publication must be given when ordering. If 100 copies or more of any publication are ordered, a discount of 25 percent is allowed.

### ANNOUNCEMENTS OF BUREAU PUBLICATIONS

There are several official sources of information as to new publications of the National Bureau of Standards. The following announcements are issued regularly by governmental agencies. In addition, many of the technical journals carry notices of new Bureau publications of interest in their respective fields.

**Technical News Bulletin.** Issued monthly by the National Bureau of Standards. Announces all new publications by members of the staff, including those appearing in outside journals. Available from the Superintendent of Documents, Government Printing Office, Washington 25, D. C. Annual subscription, \$1; \$1.35 foreign. Single copies, 10c each.

**Monthly Catalog of United States Government Publications.** Issued monthly by the Superintendent of Documents, United States Government Printing Office, Washington 25, D. C. Annual subscription, with consolidated annual index, \$3.00; \$3.75 foreign.

**Price Lists.** Publication lists prepared by the Superintendent of Documents on special subjects. These will be furnished free, on application, if the subject concerning which information is desired is stated.

**List of Selected Government Publications.** Issued semimonthly by the Superintendent of Documents. Each list is arranged alphabeti-

cally by subjects, with annotations and prices. May be obtained free from that office.

**Building Materials and Structures Reports.** The Superintendent of Documents maintains a free mailing list of addresses to receive notices of new reports in this series. An alternative method is to deposit with the Superintendent of Documents the sum of \$5, with the request that these reports be mailed to you as issued.

**Business Service Check List.** Weekly announcement of publications of the Department of Commerce. Lists titles and prices of National Bureau of Standards publications, as well as those of other offices of the Department of Commerce. Available from the Superintendent of Documents for \$1.00 a year domestic; \$1.75 foreign.

## CATALOGS OF BUREAU PUBLICATIONS

Previous catalogs and this Circular give a complete list of the titles and brief abstracts of the Bureau's publications up to June 30, 1947. These lists are available from the Superintendent of Documents, United States Government Printing Office, Washington 25, D. C., at the prices given below, or they may be available for consultation in libraries maintaining sets of Bureau Circulars.

	Cents
Circular C24, 7th edition: Publications of the Bureau of Standards 1901 to 1925. 271 pages, including brief abstracts and subject index.....	45
Circular C24 Supplement: Supplementary list of publications of the Bureau of Standards, July 1, 1925, to December 31, 1931. 214 pages, including brief abstracts and subject index.....	<del>25</del> 40
Circular 24 Supplement: Supplementary list of publications of the National Bureau of Standards, January 1, 1932, to December 31, 1941. 386 pages, including brief abstracts. The subject and author indexes cover the period 1901 to December 31, 1941.....	50
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## MAILING LISTS

Names of individuals are not placed on the Bureau's mailing lists. The principal distribution is by the Superintendent of Documents on a sales basis. A limited edition of each paper is printed for Bureau administrative needs and for official distribution to cooperating laboratories, technical organizations, Government agencies, and to leading public and educational institutions libraries. In addition, the Superintendent of Documents distributes copies of selected Bureau publications to the Government depository libraries listed below.

## DEPOSITORY LIBRARIES

The Superintendent of Documents, United States Government Printing Office, is authorized by law to furnish Government publications to designated depository libraries. The libraries listed below are now receiving certain selected publication series of the National Bureau of Standards for general reference use. Whether or not a given library has a copy of any particular publication can only be determined by inquiry at the library.

State or territory	City	Name of library
Alabama.....	Auburn.....	Alabama Polytechnic Institute.
	Birmingham.....	Birmingham Southern College, M. Paul Phillips Library
		Howard College.
		Public.
	Clayton.....	Barbour County Library.
	Florence.....	State Teachers College.
	Jacksonville.....	State Teachers College.
	Montgomery.....	State Capitol, Department of Archives and History.
		State and Supreme Court.
	Spring Hill.....	Spring Hill College, Thomas Byrne Memorial Library.
Alaska.....	Tuskegee.....	Tuskegee Institute, Hollis Burke Frissell Library.
	University.....	University of Alabama.
	College.....	University of Alaska.
Arizona.....	Juneau.....	Territorial Historical Library and Museum.
	Flagstaff.....	Arizona State Teachers College.
	Phoenix.....	Department of Library and Archives.
Arkansas.....		Phoenix Public.
	Tempe.....	Arizona State Teachers College, Matthews Library.
	Thatcher.....	Gila Junior College Library.
	Tucson.....	University of Arizona.
	Clarksville.....	College of the Ozarks.
	Conway.....	Hendrix College Library.
	Fayetteville.....	University of Arkansas.
	Hardy.....	Sharp County Public.
	Jonesboro.....	Arkansas State College.
	Russellville.....	Arkansas Polytechnic College.
California.....	Alturas.....	Modoc County Public.
	Bakersfield.....	Kern County Free.
	Berkeley.....	University of California.
	Claremont.....	Pomona College.
	Eureka.....	Eureka Free.
	Fresno.....	Fresno County Free.
	Long Beach.....	Public.
	Los Angeles.....	Los Angeles Public.
		Loyola University.
		Occidental College.
Colorado.....		University of California at Los Angeles.
		University of Southern California.
	Oakland.....	Oakland Public.
	Pasadena.....	California Institute of Technology.
	Redlands.....	University of Redlands.
	Richmond.....	Richmond Public.
	Sacramento.....	California State.
		City Free.
	San Diego.....	San Diego Public.
	San Francisco.....	Mechanics Mercantile.
Connecticut.....		San Francisco Public.
	Santa Barbara.....	Santa Barbara Public.
	Santa Rosa.....	Free Public.
	Stanford University.....	Stanford University.
	Stockton.....	Stockton Free Public.
	Torrance.....	Torrance Public.
	Boulder.....	University of Colorado.
	Colorado Springs.....	Colorado College, Coburn Library.
	Denver.....	Colorado State.
		Public.
Delaware.....		Regis College.
	Fort Collins.....	University of Denver, Mary Reed Library.
		Colorado State College of Agriculture and Mechanic Arts.
	Golden.....	Colorado School of Mines.
	Gunnison.....	Western State College.
	Pueblo.....	McClelland Public.
	Bridgeport.....	Public.
	Hartford.....	Connecticut State.
		Public.
		Trinity College.
District of Columbia..	Middletown.....	Wesleyan University.
	New Haven.....	Yale University.
	New London.....	Connecticut College, Palmer Library.
		U. S. Coast Guard Academy.
	Storrs.....	University of Connecticut.
	Waterbury.....	Silas Bronson.
	Dover.....	Delaware State.
	Newark.....	University of Delaware.
	Wilmington.....	Wilmington Institute Free.
	Washington.....	Department of Agriculture.
		Department of Interior, U. S. Geological Survey Library.
		Department of Justice.
		Department of State.
		National War College.
		Navy Department, Naval Records and Library.



State or territory	City	Name of library
District of Columbia (con't)	Washington (con't)	Post Office Department, Historical Library. Public.
Florida	Coral Gables	Treasury Department.
	De Land	University of Miami, Law Library.
	Fort Lauderdale	John B. Stetson University, Sampson Library.
	Gainesville	Fort Lauderdale Public.
	Jacksonville	University of Florida.
	Lakeland	Jacksonville Public.
	Tallahassee	Lakeland Public.
		Florida A. & M. College.
		Florida State College for Women.
		Florida State.
Georgia	Winter Park	Rollins College.
	Athens	University of Georgia, General Library.
	Atlanta	Carnegie.
		Georgia State.
	Augusta	Academy and Junior College of Augusta.
	Collegeboro	Georgia Teachers College.
	Dahlonega	North Georgia College.
	Emory University	Emory University, Asa Griggs Candler Library.
	Macon	Washington Memorial.
	Savannah	Savannah Public.
Hawaii	Honolulu	Library of Hawaii.
		University of Hawaii.
Idaho	Boise	Boise Public.
		Idaho State Law.
	Caldwell	College of Idaho, Strahorn Memorial Library.
	Moscow	University of Idaho.
	Pocatello	University of Idaho, Southern Branch.
	Rexburg	Ricks College.
Illinois	Bloomington	Illinois Wesleyan University, Buck Memorial Library.
	Carbondale	Southern Illinois State Normal University, Wheeler Library.
	Chicago	John Crerar.
		Museum of Science and Industry.
		Newberry.
		Chicago Public.
		University of Chicago.
	Evanston	Northwestern University.
	Freeport	Freeport Public.
	Galesburg	Galesburg Public.
	Jacksonville	MacMurray College.
	Joliet	Public.
	Kankakee	Olivet Nazarene College.
	Lisle	St. Procopius College.
	Monmouth	Monmouth College.
	Normal	Illinois State Normal University.
	Peoria	Peoria Public.
	Rockford	Public.
	Springfield	Illinois State, General Library Division.
	Urbana	University of Illinois.
	Wheaton	Wheaton College.
Indiana	Bloomington	Indiana University.
	Crawfordsville	Wabash College.
	Evansville	Public.
	Fort Wayne	Public.
	Gary	Gary Public.
	Greencastle	De Pauw University.
	Hanover	Hanover College.
	Huntington	City Free.
	Indianapolis	Indiana State.
		Indianapolis Public.
		Purdue University.
	La Fayette	Public.
	Muncie	University of Notre Dame.
	Notre Dame	Morrison-Reeves.
	Richmond	Indiana State Teachers College.
	Terre Haute	Valparaiso University.
	Valparaiso	Iowa State College.
Iowa	Ames	Erickson Free Public.
	Boone	Iowa State Teachers College.
	Cedar Falls	Free Public.
	Council Bluffs	Iowa State Traveling.
	Des Moines	Public.
		Carnegie Stout Free.
	Dubuque	Fairfield Free Public.
	Fairfield	Grinnell College.
	Grinnell	State University of Iowa.
	Iowa City	Graceland College.
	Lamoni	Iowa Wesleyan College, P. E. O. Memorial Library.
	Mount Pleasant	Cornell College.
	Mount Vernon	Public.
Kansas	Sioux City	Baker University.
	Baldwin City	Kansas State Teachers College of Emporia,
	Emporia	Kellogg Library.

State or territory	City	Name of library
Kansas (con't).....	Hays.....	Fort Hays Kansas State College, Forsyth Library.
	Hiawatha.....	Morrill Free Public.
	Lawrence.....	University of Kansas.
	Manhattan.....	Kansas State College of Agriculture and Applied Sciences.
	Pittsburg.....	Pittsburg Public.
	Salina.....	Kansas Wesleyan University.
	Topeka.....	Kansas State Historical Society. Kansas State.
	Wichita.....	University of Wichita.
	Ashland.....	Ashland Public.
	Bowling Green.....	Western Kentucky State Teachers College.
Kentucky.....	Danville.....	Centre College.
	Frankfort.....	Department of Library and Archives, Legislative and Law Library.
	Lexington.....	University of Kentucky.
	Lincoln Ridge.....	Lincoln Institute of Kentucky.
	Louisville.....	Louisville Free Public. University of Louisville.
	Murray.....	Murray State Teachers College.
	Somerset.....	Carnegie Public.
	Winchester.....	Kentucky Wesleyan College.
Louisiana.....	Baton Rouge.....	Louisiana State University, Law Library. Louisiana State University, Public Documents.
	Lafayette.....	Southwestern Louisiana Institute.
	Lake Charles.....	John McNeese Junior College.
	Natchitoches.....	Louisiana State Normal College.
	New Orleans.....	Tulane University, Howard-Tilton Memorial Library.
		Law Library of Louisiana.
		Louisiana State Museum.
		Loyola University.
		New Orleans Public.
	Ruston.....	Louisiana Polytechnic Institute.
Maine.....	Shreveport.....	Shreve Memorial Library.
	Augusta.....	Maine State.
	Bangor.....	Bangor Public.
	Brunswick.....	Bowdoin College.
	Lewiston.....	Bates College.
	Orono.....	University of Maine.
	Portland.....	Portland Public.
Maryland.....	Waterville.....	Colby College.
	Annapolis.....	Maryland State. U. S. Naval Academy.
	Baltimore.....	Enoch Pratt Free. Johns Hopkins University.
		Morgan State College.
		Peabody Institute.
	Chestertown.....	Washington. College, George Avery Bunting Library.
	College Park.....	University of Maryland.
	Westminster.....	Western Maryland College.
	Amherst.....	Amherst College, Converse Memorial Library.
		Massachusetts State College, Goodell Library.
Massachusetts.....	Boston.....	Boston Athenaeum. Boston Public.
		State Library of Massachusetts.
	Brookline.....	Public.
	Cambridge.....	Harvard University, Document Division Library, Littauer Center.
		Massachusetts Institute of Technology.
	Lynn.....	Lynn Public.
	New Bedford.....	Public.
	Salem.....	Essex Institute.
	Tufts College.....	Tufts College.
	Wellesley.....	Wellesley College.
Michigan.....	Williamstown.....	Williams College.
	Worcester.....	American Antiquarian Society. Free Public.
	Ann Arbor.....	University of Michigan, General Library.
	Battle Creek.....	Battle Creek Public School.
	Benton Harbor.....	Benton Harbor Public.
	Bloomfield Hills.....	Cranbrook Institute of Science Library.
	Detroit.....	Detroit Public. University of Detroit.
		Wayne University.
	East Lansing.....	Michigan State College of Agriculture and Applied Science.
	Grand Rapids.....	Grand Rapids Public.
	Houghton.....	Michigan College of Mines and Technology.
	Kalamazoo.....	Public.
	Lansing.....	Michigan State.
	Muskegon.....	Hackley Public.
	Port Huron.....	Port Huron Public.
	Saginaw.....	Hoyt Public.



State or territory	City	Name of library
Minnesota.....	Duluth.....	Duluth Public.
	Fergus Falls.....	Fergus Falls Public.
	Minneapolis.....	Public. University of Minnesota.
	Northfield.....	Carleton College. St. Olaf College.
	St. Paul.....	Minnesota Historical Society. Minnesota State. St. Paul Public.
	Saint Peter.....	Gustavus Adolphus College.
Mississippi.....	Stillwater.....	Carnegie Public.
	Columbus.....	Mississippi State College for Women, J. C. Fant Memorial Library.
	Hattiesburg.....	Mississippi Southern College.
	Jackson.....	Mississippi State. Mississippi State College.
Missouri.....	University.....	University of Mississippi.
	Cape Girardeau.....	State Teachers College.
	Columbia.....	University of Missouri.
	Fulton.....	Westminster College.
	Hannibal.....	Free Public.
	Jefferson City.....	Lincoln University.
	Kansas City.....	Missouri Supreme Court. Kansas City Public, Document Department. Rockhurst College.
	Liberty.....	University of Kansas City. William Jewell College.
Montana.....	Rolla.....	School of Mines and Metallurgy, University of Missouri.
	Springfield.....	Drury College.
	St. Joseph.....	St. Joseph Public.
	St. Louis.....	St. Louis Public. St. Louis University.
	Warrensburg.....	Washington University.
	Bozeman.....	State Teachers College.
	Butte.....	Montana State College.
	Helena.....	Montana School of Mines. Helena Public.
	Lewistown.....	Historical Society of Montana.
	Missoula.....	Fergus County High School.
Nebraska.....	Blair.....	State University of Montana.
	Crete.....	Dana College.
	Fremont.....	Doane College, Whitin Library.
	Lincoln.....	Midland College.
	Omaha.....	Nebraska State. University of Nebraska.
	Scottsbluff.....	Municipal University of Omaha Library.
Nevada.....	Carson City.....	Omaha Public.
	Reno.....	Public. Nevada State.
		University of Nevada.
New Hampshire.....	Concord.....	Nevada State Historical Society.
	Dover.....	New Hampshire State.
	Durham.....	Dover Public.
		University of New Hampshire, Hamilton Smith Library.
New Jersey.....	Hanover.....	Dartmouth College.
	Laconia.....	Laconia Public.
	Manchester.....	City Library.
	Atlantic City.....	Free Public.
	Bayonne.....	Free Public.
	Camden.....	Camden Free Public.
	Convent Station.....	College of St. Elizabeth, Santa Maria Library.
	Elizabeth.....	Public.
	Jersey City.....	Free Public.
	Madison.....	Drew University, Rose Memorial Library.
New Mexico.....	Newark.....	Public.
	New Brunswick.....	Free Public.
	Princeton.....	Rutgers University.
	Trenton.....	Princeton University.
		New Jersey State.
		Free Public.
New York.....	Albuquerque.....	University of New Mexico.
	Las Vegas.....	New Mexico Highlands University.
	Santa Fe.....	New Mexico State Law.
	Silver City.....	New Mexico State Teachers College.
	State College.....	New Mexico College of Agriculture and Mechanical Arts.
New York.....	Albany.....	New York State.
	Brooklyn.....	Brooklyn College.
		Pratt Institute.
		Public.
	Buffalo.....	St. Johns University.
	Canton.....	Grosvenor.
	Flushing.....	Buffalo Public. St. Lawrence University. Queens College.

State or territory	City	Name of library
New York (con't) . . . .	Farmingdale, L. I. . . . .	State Institute of Applied Agriculture.
	Glens Falls . . . . .	Crandall.
	Hamilton . . . . .	Colgate University.
	Ithaca . . . . .	Cornell University.
		N. Y. State College of Home Economics, Martha Van Rensselaer Hall Library.
	Jamaica . . . . .	Queens Borough Public.
	Keuka Park . . . . .	Keuka College Public.
	Newburgh . . . . .	Newburgh Free.
	New York . . . . .	College of the City of New York.
		Columbia University.
		Cooper Union.
		Fordham University.
		New York Law Institute.
		New York University.
		New York Public, Astor Branch.
		New York Public, Lenox Branch.
		Clarkson College of Technology.
	Potsdam . . . . .	Vassar College.
	Poughkeepsie . . . . .	University of Rochester, Rush Rhees Library.
	Rochester . . . . .	Union College.
	Schenectady . . . . .	St. Bonaventure College.
	St. Bonaventure . . . . .	Syracuse University.
	Syracuse . . . . .	Troy Public.
	Troy . . . . .	Utica Public.
	Utica . . . . .	Yonkers Public.
	Yonkers . . . . .	U. S. Military Academy.
	West Point . . . . .	University of North Carolina.
North Carolina . . . . .	Chapel Hill . . . . .	Queens College.
	Charlotte . . . . .	Davidson College.
	Davidson . . . . .	Duke University.
	Durham . . . . .	Agricultural and Technical College.
	Greensboro . . . . .	North Carolina State College, D. H. Hill Library.
	Raleigh . . . . .	North Carolina State Library.
		Catawba College.
	Salisbury . . . . .	Wake Forest College.
	Wake Forest . . . . .	Public Schools Library.
	Washington . . . . .	Atlantic Christian College.
North Dakota . . . . .	Wilson . . . . .	Salem College.
	Winston-Salem . . . . .	State Historical.
	Bismarck . . . . .	State Law.
	Fargo . . . . .	North Dakota Agricultural College and Experimental Station.
		University of North Dakota.
Ohio . . . . .	Grand Forks . . . . .	State Teachers College.
	Minot . . . . .	State Teachers College.
	Valley City . . . . .	Mt. Union College.
	Alliance . . . . .	Ashland College.
	Ashland . . . . .	Ohio University, Edwin Watts Chubb Library.
	Athens . . . . .	Bowling Green State University.
	Bowling Green . . . . .	Bucyrus Public.
	Bucyrus . . . . .	Miami University.
	Oxford . . . . .	Public.
	Chillicothe . . . . .	Public.
	Cincinnati . . . . .	University of Cincinnati.
	Cleveland . . . . .	Case.
		Cleveland Public.
		Western Reserve University, Adelbert College Library.
	Columbus . . . . .	Ohio State.
		Ohio State University.
		Columbus Public.
Oklahoma . . . . .	Dayton . . . . .	Dayton Public.
	Delaware . . . . .	Ohio Wesleyan University, Charles Slocum Library.
	Gambier . . . . .	Kenyon College.
	Granville . . . . .	Denison University.
	Hiram . . . . .	Hiram College.
	Marietta . . . . .	Marietta College.
	Oberlin . . . . .	Oberlin College.
	Portsmouth . . . . .	Free Public.
	Springfield . . . . .	Warder Public.
	Toledo . . . . .	Toledo Public.
	Van Wert . . . . .	Brumback Library of Van Wert County.
	Youngstown . . . . .	Youngstown Public.
	Ada . . . . .	East Central State Teachers College.
	Alva . . . . .	Northwestern State Teachers College.
	Durant . . . . .	Southeastern Teachers College.
	Edmond . . . . .	Central State Teachers College.
	Enid . . . . .	Carnegie Public.
	Langston . . . . .	Langston University.
	Norman . . . . .	University of Oklahoma.
	Oklahoma City . . . . .	Oklahoma State.
	Shawnee . . . . .	Oklahoma Baptist University.
	Stillwater . . . . .	Agriculture and Mechanical College.
	Tahlequah . . . . .	Northeastern State Teachers College.
	Tulsa . . . . .	University of Tulsa.

State or territory	City	Name of library
Oregon.....	Corvallis.....	Oregon State Agricultural College.
	Eugene.....	University of Oregon.
	Forest Grove.....	Pacific University.
	Portland.....	Library Association of Portland. Reed College.
Pennsylvania.....	Salem.....	Oregon State.
	Allentown.....	Muhlenberg College.
	Bethlehem.....	Lehigh University.
	Bradford.....	Carnegie Public.
	Carlisle.....	J. Herman Bosler Memorial Library.
	Erie.....	Erie Public.
	Harrisburg.....	Pennsylvania State.
	Haverford.....	Haverford College.
	Huntingdon.....	Juniata College.
	Lancaster.....	Franklin and Marshall College, Fackenthal Library.
	Meadville.....	Allegheny College.
	Philadelphia.....	Free Library of Philadelphia, Department of Public Documents. Mercantile. Philadelphia Commercial Museum. University of Pennsylvania.
	Pittsburgh.....	Carnegie Free Library of Allegheny. Carnegie Library. University of Pittsburgh.
	Pottsville.....	Pottsville Public.
	Reading.....	Reading Public.
	Scranton.....	Scranton Public.
	State College.....	Pennsylvania State College.
	Swarthmore.....	Swarthmore College.
	Warren.....	Warren Library Association.
	Washington.....	Washington and Jefferson College, Memorial Library.
Philippine Islands...	Williamsport.....	James V. Brown Library.
	Manila.....	Department of Agriculture and Commerce, Sci- entific Library. The National Library, Public Documents Section. University of the Philippines.
Puerto Rico.....	Mayaguez.....	University of Puerto Rico, College of Agriculture and Mechanical Arts.
Rhode Island.....	Rio Piedras.....	University of Puerto Rico.
	Kingston.....	Rhode Island State College.
	Providence.....	Brown University. Providence Public. Rhode Island State.
South Carolina.....	Westerly.....	Westerly Public.
	Charleston.....	Charleston College. Charleston Library Society.
	Clemson.....	Clemson College.
	Clinton.....	Presbyterian College.
	Columbia.....	South Carolina State. University of South Carolina.
South Dakota.....	Greenwood.....	Greenwood Public.
	Rockhill.....	Winthrop College, Carnegie Library.
	Brookings.....	South Dakota State, Lincoln Memorial Library.
	Huron.....	Huron College.
	Mitchell.....	Dakota Wesleyan University.
	Pierre.....	South Dakota Free.
	Sioux Falls.....	Carnegie Free Public.
	Spearfish.....	Black Hills Teachers College.
	Vermilion.....	University of South Dakota.
Tennessee.....	Yankton.....	Yankton College.
	Chattanooga.....	Chattanooga Public.
	Clarksville.....	Austin Peay State College.
	Johnson City.....	East Tennessee State College.
	Knoxville.....	University of Tennessee.
	Memphis.....	Cossitt.
	Murfreesboro.....	State Teachers College.
	Nashville.....	Carnegie. Joint University Libraries. Tennessee State Library.
	Sewanee.....	University of the South.
Texas.....	Abilene.....	Hardin-Simmons University.
	Austin.....	Texas State. University of Texas, Documents Acquisition.
	Brownwood.....	Howard Payne College.
	Canyon.....	West Texas State Teachers College Library.
	College Station.....	Agriculture and Mechanical College of Texas.
	Commerce.....	East Texas State Teachers College.
	Corsicana.....	Public.
	Dallas.....	Dallas Public. Southern Methodist University.
	Denton.....	Texas State College for Women, College of Indus- trial Arts.
	El Paso.....	El Paso Public.
	Fort Worth.....	Fort Worth Public. Texas Christian University.



State or territory	City	Name of library
Texas (con't)	Galveston	Rosenberg Library.
	Georgetown	Southwestern University.
	Gilmer	East Mountain High School.
	Houston	Houston Public.
	Kingsville	Texas College of Arts and Industries.
	Lubbock	Texas Technological College.
	Marshall	Bishop College.
	San Antonio	Carnegie.
Utah	Waco	Baylor University.
	Ephraim	Snow College.
	Logan	Utah State Agricultural College.
	Ogden	Carnegie Free.
	Provo	Brigham Young University.
	Salt Lake City	University of Utah.
Vermont	Burlington	University of Vermont.
	Middelbury	Middelbury College.
Virginia	Montpelier	Vermont State.
	Northfield	Norwich University.
	Blacksburg	Virginia Polytechnic Institute.
	Bridgewater	Bridgewater College.
	Danville	Averett College.
	Emory	Emory and Henry College.
	Fredericksburg	Mary Washington College.
	Hampden Sydney	Hampden Sydney College.
	Lexington	Virginia Military Institute.
		Washington and Lee University.
	Norfolk	Norfolk Public.
Washington	Petersburg	Virginia State College.
	Richmond	Virginia State.
	Salem	Roanoke College, Bittle Memorial Library.
	University	University of Virginia.
	University of Richmond P. O.	University of Richmond.
	Williamsburg	William and Mary College.
	Everett	Everett Public.
	Olympia	Washington State.
	Pullman	State College of Washington.
	Seattle	Seattle Public.
West Virginia		University of Washington.
	Spokane	Spokane Public.
	Tacoma	College of Puget Sound.
		Tacoma Public.
	Walla Walla	Whitman College.
	Athens	Concord State Normal.
	Charleston	State Library, Department of Archives and History.
	Elkins	Davis and Elkins College.
	Fairmont	Fairmont State Teachers College.
	Harpers Ferry	Storer College, Roger Williams Library.
Wisconsin	Huntington	Marshall College, James E. Morrow Library.
	Institute	West Virginia State College.
	Morgantown	West Virginia University.
	Salem	Salem College.
	Appleton	Lawrence College.
	Beloit	Beloit College.
	Eau Claire	Eau Claire Public.
	Fond du Lac	Fond du Lac Public.
	La Crosse	Public.
	Madison	State Historical Society.
Wyoming		University of Wisconsin.
		Wisconsin State.
	Milwaukee	Law Library of Milwaukee County.
		Milwaukee Public.
	Racine	Racine Public.
	Superior	Superior Public.
		Superior State Teachers College.
	Casper	Natrona County Public.
	Cheyenne	Wyoming State.
	Laramie	University of Wyoming.

## BOUND VOLUMES

Bound volumes containing the Scientific Papers and the Technologic Papers may be purchased at the prices indicated below. Only seven bound volumes of the Technologic Papers, volumes 16 to 22, consecutively paged, were printed. Earlier Technologic Papers were published as separate articles, individually paged.

The first 14 volumes of the Scientific Papers were issued as the "Bulletin," and the separate papers were called "Reprints." Some

of these papers are available for purchase only in the quarterly numbers of the Bulletin; see list below.

In July 1928 the Scientific and Technologic Papers were combined and issued under the title "Bureau of Standards Journal of Research," and beginning with volume 13, July 1934, the name of the Journal was changed to "Journal of Research of the National Bureau of Standards."

# SCIENTIFIC PAPERS

Volume	Issued	Containing		Available from Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C., at prices indicated		
		Number	Scientific paper numbers	Paper-bound number	Buckram-bound volume	Separately printed title page (TP), contents (C), and index (I), for unbound sets
				<i>Cents</i>		
1.....	1904-05	1	S1 to S8.....	.....		
		2	S9 to S13.....	.....		
		3	S14 to S25.....	.....		
2.....	1906	1	S26 to S30.....	.....		
		2	S31 to S39.....	.....		
		3	S40 to S46.....	.....		
3.....	1907	1	S47 to S54.....	.....		
		2	S55 to S61.....	.....	\$2	
		3	S62 to S65.....	.....		
		4	S66 to S69.....	.....		
4.....	1907-08	1	S70 to S76.....	.....		
		2	S77 to S80.....	.....		
		3	S81 to S86.....	.....		
		4	S87 to S92.....	.....		
5.....	1908-09	1	S93 to S96.....	.....		
		2	S97 to S104.....	.....	\$2	
		3	S105 to S108.....	.....		
		4	S109 to S115.....	.....		
6.....	1909-10	1	S116 to S123.....	.....		
		2	S124 to S130.....	.....	\$2	
		3	S131 to S136.....	.....		
		4	S137 to S142.....	.....		
7.....	1911	1	S143 to S150.....	.....		
		2	S151 to S158.....	.....	\$2	TP and C, 5c; I, 5c
		3	S159 to S165.....	.....		
		4	S166 to S168.....	.....		
8.....	1912	1	S169.....	.....		
		2	S170 to S173.....	.....		
		3	S174 to S181.....	.....		
		4	S182 to S186.....	.....		
9.....	1913	1	S187 to S193.....	.....		
		2	S194 to S196.....	.....		
		3	S197.....	.....		
10.....	1914	4	S198 to S203.....	.....		
		1	S204 to S206.....	25		
		2	S207 to S212.....	25	\$2	
		3	S213 to S218.....	25		
		4	S219 to S222.....	25		
11.....	1915	1	S223 to S229.....	25		
		2	S230 to S231.....	25		
		3	S232 to S237.....	25		
		4	S238 to S244.....	25		
12.....	1915-16	1	S245 to S250.....	25		
		2	S251 to S254.....	25	\$2	TP and C, 5c
		3	S255 to S257.....	25		
		4	S258 to S265.....	25		
13.....	1916-17	1	S266 to S271.....	25		
		2	S272 to S278.....	25	\$2	
		3	S279 to S285.....	25		
		4	S286 to S294.....	25		
14.....	1918-19	1	S295 to S302.....	.....		
		2	S303 to S309.....	25	\$2	TP and C, 5c
		3	S310 to S317.....	25		
		4	S318 to S329.....	25		
15.....	1919-20	.....	S330 to S368.....	.....	\$2	I, TP, and C, 5c
16.....	1920	.....	S369 to S404.....	.....	\$2	TP and I, 5c
17.....	1922	.....	S405 to S438.....	.....	\$2	TP and I, 5c
18.....	1922-23	.....	S439 to S468.....	.....		
19.....	1923-24	.....	S469 to S497.....	.....		TP and I, 5c
20.....	1924-26	.....	S498 to S523.....	.....		TP and I, 5c
21.....	1926-27	.....	S524 to S546.....	.....		TP and I, 5c
22.....	1927-28	.....	S547 to S572.....	.....		TP and I, 5c

# TECHNOLOGIC PAPERS <sup>1</sup>

Volume	Containing technologic papers <sup>2</sup>	Bound volume	Combined title page contents and index for un-bound sets <sup>3</sup>	Issued	Volume	Containing technologic papers <sup>2</sup>	Bound volume	Combined title page contents and index for un-bound sets <sup>3</sup>	Issued
			<i>Cents</i>					<i>Cents</i>	
1.....	T1 to T11.....			1910-12	12.....	T121 to T142.....			1919
2.....	T12 to T19.....			1912-14	13.....	T143 to T169.....			1919-20
3.....	T20 to T31.....			1911-16	14.....	T170 to T183.....			1920-21
4.....	T32 to T42.....			1913-14	15.....	T184 to T202.....			1921
5.....	T43 to T53.....			1914-15	16.....	T203 to T220.....	\$2	5	1921-22
6.....	T54 to T60.....			1915-16	17.....	T221 to T247.....	\$2	5	1922-24
7.....	T61 to T73.....			1916-17	18.....	T248 to T272.....	\$2	5	1924-25
8.....	T74 to T84.....			1916-17	19.....	T273 to T301.....	\$2	5	1924-25
9.....	T85 to T100.....			1916-17	20.....	T302 to T327.....	\$2	5	1925-26
10.....	T101 to T108.....			1917-18	21.....	T328 to T352.....	\$2	5	1926-27
11.....	T109 to T120.....			1918-19	22.....	T353 to T370.....	\$3	5	1927-28

<sup>1</sup> Prior to volume 16, this series was issued as individual papers only, not consecutively paged.

<sup>2</sup> Suggested volume grouping up to Technologic Paper 202.      <sup>3</sup> Not issued prior to volume 16.

# RESEARCH PAPERS

Volume	Issued	Number	Containing research papers	Available from Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C., at prices indicated		
				Paper-bound number	Bound volume	Separately printed combined title page, contents, and index for combined sets
				<i>Cents</i>		<i>Cents</i>
1.....	1928	1	RP1 to RP5.....			
		2	RP6 to RP10.....			
		3	RP11 to RP15.....			
		4	RP16 to RP23.....			
		5	RP24 to RP31.....			
		6	RP32 to RP36.....			
2.....	1929	1	RP37.....			
		2	RP38 to RP44.....			
		3	RP45 to RP49.....			
		4	RP50 to RP59.....			
		5	RP60 to RP66.....			
		6	RP67 to RP76.....			
3.....	1929	1	RP77 to RP90.....	30		
		2	RP91 to RP98.....	50		
		3	RP99 to RP107.....	50	\$2.75	5
		4	RP108 to RP111.....	40		
		5	RP112 to RP119.....	50		
		6	RP120 to RP128.....			
4.....	1930	1	RP129 to RP139.....			
		2	RP140 to RP151.....	40		
		3	RP152 to RP159.....		\$2.75	5
		4	RP160 to RP166.....	40		
		5	RP167 to RP175.....			
		6	RP176 to RP182.....	40		
5.....	1930	1	RP183 to RP193.....			
		2	RP194 to RP210.....			
		3	RP211 to RP229.....		\$2.75	5
		4	RP230 to RP242.....			
		5	RP243 to RP253.....			
		6	RP254 to RP258.....	40		
6.....	1931	1	RP259 to RP267.....	40		
		2	RP268 to RP278.....	40		
		3	RP279 to RP291.....		\$2.75	5
		4	RP292 to RP302.....			
		5	RP303 to RP313.....			
		6	RP314 to RP328.....			



# RESEARCH PAPERS—Continued

Volume	Issued	Number	Containing research papers	Available from Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C., at prices indicated		
				Paper-bound number	Bound volume	Separately printed combined title page, contents, and index for combined sets
				<i>Cents</i>		<i>Cents</i>
7.....	1931	1	RP329 to RP338.....	.....	\$3.00	5
		2	RP339 to RP347.....	.....		
		3	RP348 to RP360.....	.....		
		4	RP361 to RP371.....	.....		
		5	RP372 to RP386.....	.....		
		6	RP387 to RP395.....	40	\$3.00	5
		1	RP396 to RP406.....	40		
		2	RP407 to RP415.....	40		
		3	RP416 to RP426.....	40		
		4	RP427 to RP433.....	40		
		5	RP434 to RP445.....	.....	\$3.00	5
		6	RP446 to RP452.....	40		
		1	RP453 to RP460.....	20		
		2	RP461 to RP470.....	25		
		3	RP471 to RP481.....	25		
		4	RP482 to RP492.....	.....	\$3.00	5
		5	RP493 to RP500.....	.....		
		6	RP501 to RP511.....	.....		
		1	RP512 to RP521.....	.....		
		2	RP522 to RP530.....	.....		
		3	RP531 to RP539.....	25	\$3.00	5
		4	RP540 to RP548.....	25		
		5	RP549 to RP560.....	25		
		6	RP561 to RP572.....	25		
		1	RP573 to RP583.....	.....		
		2	RP584 to RP592.....	25	\$3.00	5
		3	RP593 to RP599.....	.....		
		4	RP600 to RP608.....	.....		
		5	RP609 to RP619.....	.....		
		6	RP620 to RP629.....	25		
		1	RP630 to RP638.....	25	\$3.00	5
		2	RP639 to RP652.....	.....		
		3	RP653 to RP665.....	25		
		4	RP666 to RP675.....	.....		
		5	RP676 to RP684.....	.....		
		6	RP685 to RP690.....	.....	\$3.00	5
		1	RP691 to RP698.....	25		
		2	RP699 to RP708.....	25		
		3	RP709 to RP717.....	25		
		4	RP718 to RP728.....	25		
		5	RP729 to RP742.....	25	\$3.00	5
		6	RP743 to RP752.....	.....		
		1	RP753 to RP758.....	.....		
		2	RP759 to RP765.....	.....		
		3	RP766 to RP774.....	.....		
		4	RP775 to RP783.....	.....	\$3.00	5
		5	RP784 to RP793.....	25		
		6	RP794 to RP803.....	.....		
		1	RP804 to RP814.....	.....		
		2	RP815 to RP821.....	25		
		3	RP822 to RP831.....	25	\$3.00	5
		4	RP832 to RP839.....	25		
		5	RP840 to RP848.....	25		
		6	RP849 to RP856.....	.....		
		1	RP857.....	.....		
		2	RP858 to RP867.....	.....	\$3.00	5
		3	RP868 to RP873.....	.....		
		4	RP874 to RP880.....	25		
		5	RP881 to RP888.....	.....		
		6	RP889 to RP898.....	25		
		1	RP899 to RP906.....	.....	\$3.00	5
		2	RP907 to RP912.....	25		
		3	RP913 to RP924.....	.....		
		4	RP925 to RP932.....	25		
		5	RP933 to RP945.....	25		
		6	RP946 to RP956.....	.....		

# RESEARCH PAPERS—Continued

Volume	Issued	Number	Containing research papers	Available from Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C., at prices indicated		
				Paper-bound number	Bound volume	Separately printed combined title page, contents, and index for combined sets
				Cents		Cents
18.....	1937	1	RP957 to RP965.....			
		2	RP966 to RP974.....			
		3	RP975 to RP982.....		\$3.00	5
		4	RP983 to RP989.....			
		5	RP990 to RP999.....			
		6	RP1000 to RP1005.....	25		
19.....	1937	1	RP1006 to RP1015.....			
		2	RP1016 to RP1022.....	25		
		3	RP1023 to RP1030.....	25	\$3.00	5
		4	RP1031 to RP1039.....	25		
		5	RP1040 to RP1049.....	25		
		6	RP1050 to RP1058.....	25		
20.....	1938	1	RP1059 to RP1068.....	25		
		2	RP1069 to RP1077.....	25		
		3	RP1078 to RP1084.....	25	\$3.00	5
		4	RP1085 to RP1091.....			
		5	RP1092 to RP1101.....			
		6	RP1102 to RP1109.....	25		
21.....	1938	1	RP1110 to RP1119.....	30		
		2	RP1120 to RP1128.....	30		
		3	RP1129 to RP1136.....	30	\$3.00	
		4	RP1137 to RP1142.....	30		
		5	RP1143 to RP1150.....	30		
		6	RP1151 to RP1162.....	30		
22.....	1939	1	RP1163 to RP1171.....	30		
		2	RP1172 to RP1178.....	30		
		3	RP1179 to RP1188.....	30	\$3.00	5
		4	RP1189 to RP1199.....	30		
		5	RP1200 to RP1208.....	30		
		6	RP1209 to RP1217.....	30		
23.....	1939	1	RP1218 to RP1227.....	30		
		2	RP1228 to RP1236.....	30		
		3	RP1237 to RP1244.....	30	\$3.00	5
		4	RP1245 to RP1251.....			
		5	RP1252 to RP1258.....			
		6	RP1259 to RP1265.....	30		
24.....	1940	1	RP1266 to RP1272.....	30		
		2	RP1273 to RP1279.....			
		3	RP1280 to RP1286.....	30	\$3.00	5
		4	RP1287 to RP1294.....	30		
		5	RP1295 to RP1301.....	30		
		6	RP1302 to RP1309.....	30		
25.....	1940	1	RP1310 to RP1317.....	30		
		2	RP1318 to RP1323.....	30		
		3	RP1324 to RP1332.....	30	\$3.00	5
		4	RP1333 to RP1340.....	30		
		5	RP1341 to RP1345.....	30		
		6	RP1346 to RP1353.....	30		
26.....	1941	1	RP1354 to RP1361.....	30		
		2	RP1362 to RP1367.....	30		
		3	RP1368 to RP1374.....	30	\$3.00	5
		4	RP1375 to RP1382.....	30		
		5	RP1383 to RP1389.....			
		6	RP1390 to RP1397.....	30		
27.....	1941	1	RP1398 to RP1405.....			
		2	RP1406 to RP1414.....	30		
		3	RP1415 to RP1422.....	30	\$3.00	
		4	RP1423 to RP1428.....	30		
		5	RP1429 to RP1434.....	30		
		6	RP1435 to RP1443.....	30		
28.....	1942	1	RP1444 to RP1448.....	30		
		2	RP1449 to RP1454.....	30		
		3	RP1455 to RP1460.....	30	\$3.00	5
		4	RP1461 to RP1467.....	30		
		5	RP1468 to RP1472.....	30		
		6	RP1473 to RP1479.....	30		

# RESEARCH PAPERS—Continued

Volume	Issued	Number	Containing research papers	Available from Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C., at prices indicated		
				Paper-bound number	Bound volume	Separately printed combined title page, contents, and index for combined sets
				<i>Cents</i>		<i>Cents</i>
29.....	1942	1	RP1480 to RP1488.....	30	\$3.00	5
		2	RP1489 to RP1494.....	30		
		3	RP1495 to RP1498.....	30		
		4	RP1499 to RP1501.....	30		
		5	RP1502 to RP1506.....	30		
30.....	1943	6	RP1507 to RP1512.....	30	\$3.00	5
		1	RP1513 to RP1518.....	30		
		2	RP1519 to RP1525.....	30		
		3	RP1526 to RP1530.....	30		
		4	RP1531 to RP1536.....	30		
31.....	1943	5	RP1537 to RP1540.....	30	\$3.00	5
		6	RP1541 to RP1544.....	30		
		1	RP1545 to RP1548.....	30		
		2	RP1549 to RP1552.....	30		
		3	RP1553 to RP1557.....	30		
32.....	1944	4	RP1558 to RP1562.....	30	\$3.00	5
		5	RP1563 to RP1566.....	30		
		6	RP1567 to RP1569.....	30		
		1	RP1570 to RP1572.....	30		
		2	RP1573 to RP1575.....	30		
33.....	1944	3	RP1576 to RP1579.....	30	\$3.00	5
		4	RP1580 to RP1583.....	30		
		5	RP1584 to RP1587.....	30		
		6	RP1588 to RP1591.....	30		
		1	RP1592 to RP1596.....	30		
34.....	1945	2	RP1597 to RP1601.....	30	\$3.00	5
		3	RP1602 to RP1605.....	30		
		4	RP1606 to RP1611.....	30		
		5	RP1612 to RP1617.....	30		
		6	RP1618 to RP1623.....	30		
35.....	1945	1	RP1624 to RP1630.....	30	\$3.00	5
		2	RP1631 to RP1637.....	30		
		3	RP1638 to RP1644.....	30		
		4	RP1645 to RP1650.....	30		
		5	RP1651 to RP1655.....	30		
36.....	1946	6	RP1656 to RP1659.....	30	\$3.00	5
		1	RP1660 to RP1663.....	30		
		2	RP1664 to RP1667.....	30		
		3	RP1668 to RP1670.....	30		
		4	RP1671 to RP1675.....	30		
37.....	1946	5	RP1676 to RP1680.....	30	\$3.00	5
		6	RP1681 to RP1687.....	30		
		1	RP1688 to RP1692.....	30		
		2	RP1693 to RP1699.....	30		
		3	RP1700 to RP1704.....	30		
38.....	1947	4	RP1705 to RP1711.....	30	\$4.00	
		5	RP1712 to RP1717.....	30		
		6	RP1718 to RP1722.....	30		
		1	RP1723 to RP1729.....	30		
		2	RP1730 to RP1735.....	30		
39.....	1947	3	RP1736 to RP1741.....	30	\$4.00	
		4	RP1742 to RP1746.....	30		
		5	RP1747 to RP1750.....	30		
		6	RP1751 to RP1757.....	30		
		1	RP1758 to RP1764.....	30		
40.....	1947	2	RP1765 to RP1772.....	30	\$4.00	
		3	RP1773 to RP1779.....	60		
		4	RP1780 to RP1786.....	40		
		5	RP1787 to RP1795.....	55		
		6	RP1796 to RP1806.....	45		

## 2. PERIODICALS OF THE BUREAU

### JOURNAL OF RESEARCH OF THE NATIONAL BUREAU OF STANDARDS

Complete scientific reports of the Bureau's research and development, both experimental and theoretical, in physics, chemistry, and



engineering and the results of test and instrumentation activities in these fields are printed in this Journal. The subject matter of the reports embraces the fields of electricity, electronics, atomic physics, applied mathematics, mechanics and sound, radio and radio propagation, optics, heat and power, metallurgy, metrology, ordnance, physical chemistry, mineral products, organic and fibrous materials, and building technology. Since the inception of the Journal of Research in 1928, over 1,800 Research Papers have been published. Titles and abstracts of these papers are included in this Circular.

#### NATIONAL BUREAU OF STANDARDS TECHNICAL NEWS BULLETIN

This monthly publication summarizes the current research, development, and test activities of the Bureau. The articles are brief, with emphasis on the results of research and their significance, chosen for their importance to other scientists, engineers, and to industry. Resumes of longer research reports, important national and international conferences on fundamental science in which the Bureau has represented the Nation, and a bibliography of all publications by members of the staff as published are included. Within its 12 monthly pages the Bulletin is designed to give a succinct account of the current work of the Bureau.

#### BASIC RADIO PROPAGATION PREDICTIONS

This is a monthly publication for those concerned with radio communication in determining the best sky-wave frequencies over any path at any time of day for average conditions for the month of prediction, which are made three months in advance. Charts of extraordinary-wave critical frequency for the F2 layer and of maximum usable frequency for a transmission distance of 4,000 km, of highest frequency of sporadic-E in excess of 15 Mc are included. In addition, there are various maps, charts, diagrams, and nomograms needed to make practical application of the world-contour charts, together with examples of their use.

ANNUAL SUBSCRIPTION	United States Canada, Cuba Mexico Newfoundland Republic of Panama	Other <sup>1</sup> coun- tries
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<sup>1</sup> Additional amount for postage not required.

### 3. TITLES AND ABSTRACTS OF PUBLICATIONS

Where prices are shown the publication may be purchased from the Superintendent of Documents, U. S. Government Printing Office, Washington 25, D. C. If the price is omitted, the publication is out of print, but may be consulted in libraries maintaining reference sets of Bureau publications. Abstracts of publications issued prior to January 1, 1942, are included in Circular C24 and Supplements.

The letter-symbol designations given below are used in this Circular for the publication series indicated, and these letters should be included with the serial number in all references to Bureau publications.

S, Scientific Papers.  
T, Technologic Papers.  
J, Journal of Research.  
RP, Research Papers.  
C, Circulars.  
H, Handbooks.  
M, Miscellaneous Publications.

R, Simplified Practice Recommendations.  
CS, Commercial Standards.  
BMS, Building Materials and Structures Reports.  
BH, Building and Housing Publications.  
MT, Mathematical Tables.

## SCIENTIFIC PAPERS

Results of research in science and technology were reported in the Scientific Papers. The first 14 volumes of the Scientific Papers were issued as the "Bulletin of the Bureau of Standards" and the separate papers were called "Reprints".

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- RP1443. A resistor furnace, with some preliminary results up to 2,000°C. R. F. Geller. 5c.
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RESEARCH PAPERS FROM JOURNAL OF RESEARCH OF THE NATIONAL BUREAU OF STANDARDS, VOLUME 28, JANUARY—JUNE 1942

- RP1444. The tee-bend test to compare the welding quality of steels. George A. Ellinger, A. G. Bissell, and Morgan L. Williams.

A bend test for comparing the welding quality of steels is described in this paper. Specimens of fillet-welded T-sections of a number of low-alloy high-tensile steels were bent in special testing jigs at room temperature and at temperatures as low as -20° F. Several criteria, such as maximum load, angle at maximum load, type and location of fractures, were used to compare the specimens. A special method of statistical analysis, which is described in detail in the paper, was used to evaluate the data and to compare and rate the welding quality of the steels. 49 p. 30c.

- RP1445. Expansivity of a Vycor brand glass. James B. Saunders.

In a study of a new glass (96 percent silica, glass No. 790) used in heat-resisting glassware, its expansivity is compared with that of fused quartz. For this comparison a modification of Fizeau's method for determining very small differences in linear expansion was used and is presented. This method has the advantage of permitting the use of relatively long samples, the procurement of very sharp and well-defined interference bands, and the almost complete elimination of the effect of changes in the refractive index of air on the results.

The results indicate that the No. 790 glass has a coefficient of expansion approximately twice that of fused quartz at room temperature, an expansivity equal to fused quartz at approximately 300° C, and an expansivity less than one-half of that for fused quartz in the neighborhood of 700° C. 5 p. 5c.

- RP1446. Soil-corrosion studies, 1939. Coatings for the protection of metals underground. Kirk H. Logan.

In this paper is reported the condition of specimens of metallic and nonmetallic coatings after exposure to soils for periods ranging from 2 to 16 years. Conclusions previously drawn relative to the protective value of zinc and lead coatings are generally confirmed by the latest inspections. A specially applied zinc coating prevented serious pitting in 16 soils over a 16-year period, but a commercial coating of the same weight, exposed to more corrosive soils, did not prevent pitting entirely during the initial 2-year period. Lead corrodes sufficiently in many soils to render lead coatings unsatisfactory. Tin applied as a protective coating was of little benefit in reducing the corrosion of copper in soils. A 7-year-old vitreous enamel, two 7-year-old hard-rubber coatings, and a 2-year-old baked synthetic resin coating have shown little or no evidence of failure 15 p. 5c.

- RP1447. Elastic properties of some alloy cast irons. Alexander I. Krynsky and Charles M. Saeger, Jr.

Transverse-strength properties were determined on 1.2-in.-diameter test bars made from three types of alloy iron heated, before casting, to the maximum temperatures of 1,400°, 1,500°, 1,600°, and 1,700° C. The bars were vertically cast, bottom-poured in green-sand molds, at a temperature of 100°, 150°, 200°, or 250° C above



the liquidus. Total, plastic, and elastic deflection, modulus of rupture, relative moduli of elasticity, and total, plastic, and elastic resilience were determined, and the microstructure of the test bars was examined. Comparative values of four different relative moduli of elasticity relating to the same test bars but calculated by different methods are discussed. Comparison of transverse test properties of alloy and plain carbon irons is made. 22 p. 15c.

RP1448. Application of the dropping-mercury electrode to the investigation of the polyhydroxy acids and lactones. Harry Matheson, Horace S. Isbell, and Edgar Reynolds Smith.

The polarographic method is used in a study of the polyhydroxymonocarboxylic acids, their lactones, lactides, and other condensation products. With a tetraethylammonium chloride environment, polarographic waves are obtained which show the behavior of the hydroxy acids and their lactones with respect to electrolytic reduction and the products which they form in dilute aqueous solution.

Freshly prepared solutions of the aldonic acids give the ordinary hydrogen wave but do not give waves which correspond to the reduction of the carboxyl group. When a solution containing an aldonic acid is allowed to stand, the wave due to the hydrogen ion decreases and a wave caused by the gamma lactone appears. In the presence of oxygen a wave, apparently caused by some substance produced by the interaction of the sugar acid, mercury, and oxygen, forms at about  $-1.1$  v. The formation of this wave is accompanied by a corresponding decrease in the hydrogen wave. Freshly prepared solutions of the delta lactones of the aldonic acids give waves at about  $-2.3$  v, with respect to a mercury anode, which appear to be due to the reduction of the lactones. The heights of these waves decrease with time until, after several hours, they disappear. The absence of an appreciable delta lactone wave in a  $0.01$  *M* aqueous solution of an aldonic acid shows that the position of the equilibrium between the free acid and the delta lactone is far toward the free acid. The gamma lactones of the aldonic acids give polarographic waves at potentials slightly higher than the delta lactones. When a solution containing a gamma lactone is allowed to stand, the height of the gamma lactone wave decreases while a wave corresponding to the reduction of the hydrogen ion appears. The inflection points for the gamma lactone waves vary only slightly with the configuration of the groups comprising the lactone structure. This small variation in the inflection points shows a regularity which indicates that the stereomeric positions of the hydroxyl groups are of importance. When the hydroxyl of carbon 2 and the residual carbon group attached to carbon 4 are in the *cis* position, the reduction potential seems to be higher than it is when these groups are in the *trans*-position. 37 p. 10c.

RP1449. An absolute determination of the ampere, using helical and spiral coils. Roger W. Curtis, Raymond L. Driscoll, and Charles L. Critchfield.

The value of an electric current has been measured in absolute units by a current balance, and simultaneously in international units by standard cells and standard resistors. In the current balance a subdivided helix served as the two fixed coils and, as the moving coil, either a short helix or a compact spiral. The two moving coils were the same ones that were described in a previous paper in which the fixed coils were spirals.

The value obtained when using these two moving coils and the subdivided helix differs by only 4 parts in a million from the value obtained when using these moving coils and spirally wound fixed coils. These values are, however, somewhat different from those obtained when using multilayer coils wound with copper wire. The relationship between the absolute and international ampere, from the most dependable measurements at the National Bureau of Standards, may be expressed as

$$1 \text{ NBS international ampere} = 0.999\,850 \text{ absolute ampere.}$$

In the preceding paper published by members of the Bureau staff on this subject the value given was  $1 \text{ NBS international ampere} = 0.999\,860 \text{ absolute ampere.}$  25 p. 10c.

RP1450. Rectangular plate loaded along two adjacent edges by couples in its own plane. William R. Osgood.

A. and L. Föppl give an approximate solution for the stresses in the rectangular knee of an L-shaped plate loaded by couples acting on the legs in the plane of the plate. A solution is presented here that is exact in the sense that the equations of equilibrium and the condition of compatibility (for two-dimensional systems) are satisfied at every point. Small self-equilibrated stresses remain along the free edges of the knee. 5 p. 5c.



RP1451. Spark spectrographic analysis of commercial tin. Bourdon F. Scribner.

A procedure is described in detail for the simultaneous spectrographic determination of antimony, arsenic, bismuth, cadmium, copper, indium, iron, lead, silver, and zinc in tin metal of commercial grades. The preparation of standards and samples by chill-casting of tin in open molds and in evacuated tubes is described. The use of a press is found convenient in forming electrodes from tin metal. The characteristics of the tin spark under varied operating conditions are discussed in connection with the selection of optimum conditions of excitation. Application of the step sector provides a means of extending the range of line intensity measurements with the microphotometer as well as for plate calibration. Rapid reduction of the photometric measurements to intensities is made by a modified graphical calculator. The shapes of the analytical curves derived from measurements on tin standards are compared, and deviations from the ideal case are discussed. Repeated determinations on homogeneous samples show a standard deviation of from 1.0 to 2.5 percent. Single determinations in routine analysis are estimated to fall within 5 percent of the actual concentration, with few exceptions. The analyses are carried out on groups of six samples in a working time of 5 minutes per determination. 26 p. 10c.

RP1452. Calculation of protein-anion affinity constants from acid titration data Jacinto Steinhart.

It has been shown earlier that the titration curves of wool and other proteins obtained with different strong acids differ widely in position with respect to the pH coordinate. By assuming that these differences were due to combination of the protein with anions as well as with hydrogen ions, it was possible to calculate from the pH of the midpoint of each curve numerical values of the affinity of each anion for wool. In the present paper, modifications of the equations for calculating anion affinity are described. It is shown that the new equations described the titration curves as a whole instead of merely the positions of their midpoints. The new forms are also shown to describe the effects of the presence of salts on the titration curves at least as adequately as did the earlier ones. 9 p. 5c.

RP1453. Further investigations of the affinities of anions of strong acids for wool protein. Jacinto Steinhart, Charles H. Fugitt, and Milton Harris.

Titration curves of wool with 18 strong acids at 0°, 25°, or 50° C have been added to the data for 19 others presented earlier. Several have been investigated at more than one temperature. The reversibility of the equilibria measured has been demonstrated quantitatively. New anion-wool dissociation constants, based on modifications of equations previously used to calculate anion-wool affinities, are tabulated for 33 anions, and heats of dissociation of a few anion-wool complexes are also given. The previously reported tendency of affinity to rise with molecular-weight is confirmed; fairly consistent relationships between the affinity and the molecular weights of strong organic acids appear. 16 p. 5c.

RP1454. Intercomparison of platinum resistance thermometers between -190° and 445°C. Harold J. Hoge and Ferdinand G. Brickwedde.

Eight platinum resistance thermometers satisfying the requirements of the International Temperature Scale were calibrated on the international scale and intercompared from -190° to 445° C. The  $\delta$ 's of the Callendar-Van Dusen equations for seven of these thermometers ranged from 1.49375 to 1.49862. The  $\delta$  for the eighth thermometer, *E*, was 1.51155. After minimizing the effects of relative calibration errors, the maximum difference between the readings of the group of seven thermometers was 7 millidegrees between -190° and 0° C and 1.3 millidegrees between 0° and 100° C. Maximum differences from the mean were 4.6 and 0.3 millidegree, respectively. For thermometer *E*, deviations from the mean of the other seven were 15 millidegrees at -110° C and 3 millidegrees at +50° C. Tables of differences between readings of platinum resistance thermometers arising from assumed calibration errors at the fixed points were calculated and are included. 24 p. 10c.

RP1455. An experimental study of beater practice in the manufacture of offset papers. Charles G. Weber, Merle B. Shaw, Martin N. Geib, and Martin J. O'Leary.

Sixty-three experimental papers were made in the Bureau's semicommercial mill in studies to determine the relationship between the mechanical beating of the fibers and the properties of paper for multicolor offset printing. A series of papers was made from each of the kinds of wood fibers commonly used in offset papers and from various mixtures of these fibers. Each series comprised papers made with widely different degrees of beating, and the effects of the variations were determined by laboratory and printing tests of the papers.

The data obtained indicate that for the best results in multicolor printing, the papers should be made with the minimum of beating necessary to obtain the required formation and finish. The formation of gel on the fibers should be carefully controlled, because the high strength associated with gel, particularly high folding endurance, is directly opposed to several of the properties most important in multicolor lithography.

The admixture of filler pulp with a strong pulp such as sulfite lessens the adverse effects of beating and assists in obtaining suitable formation and finish. The best all-around results were obtained with sulfite-soda and sulfate-soda mixtures. Deinked book stock had excellent opacity, but papers containing appreciable amounts of it curled excessively. 24 p. 10c.

RP1456. Spectrophotometric determination of dysprosium, holmium, erbium, thulium, and ytterbium. Clement J. Rodden.

The transmittancies of solutions of the nitrates of dysprosium, holmium, erbium, thulium, and ytterbium were measured, over the range 350 to 1,000  $\mu\mu$ , by means of a double-monochromator photoelectric spectrophotometer. Terbium and yttrium show no appreciable absorption in this range. The bands found most suitable for determination of the five elements are: for dysprosium, at 910  $\mu\mu$ ; for holmium, at 643  $\mu\mu$ ; for erbium, at 521  $\mu\mu$  and 653  $\mu\mu$ ; for thulium, at 684  $\mu\mu$ ; and for ytterbium, at 950  $\mu\mu$  and 973  $\mu\mu$ .

Measurements were also made of the variation with concentration of the transmittancies of solutions of the nitrates of the five elements at the wavelengths given. The results obtained were applied to the analysis of several mixtures of rare-earth oxides. The procedure supplements a similar one, previously published, for the analysis of mixtures of rare earths of the cerium group. 13 p. 10c.

RP1457. Dielectric constant, power factor, and conductivity of the system rubber-calcium carbonate. Arnold H. Scott and Archibald T. McPherson.

The dielectric constants and power factors of mixtures of calcium carbonate with Vistanex and with natural rubber were determined at 1 and 100 kilocycles per second. There was little difference between the values at the two frequencies. Two different formulas were found to express the dielectric constants of the mixtures as functions of the dielectric constants of the respective components. The dielectric constant of the pure calcium carbonate employed was determined by the method of liquid mixtures. The power factors of the rubber-calcium carbonate mixtures were intermediate between those of the components. The conductivities of the Vistanex-calcium carbonate mixtures measured at the end of 1 minute of electrification were intermediate between those of the components, but the conductivities of the mixtures of natural rubber and calcium carbonate seemed to go through a minimum. 18 p. 10c.

RP1458. Temperature estimates of the planet Mars, 1924 and 1926. W. W. Coberly.

In earlier publications (S512 and S553), data were given on the planetary radiation emanating from different parts of the surface of Mars as measured with a thermocouple and filters. From these radiometric measurements, planetary temperatures were calculated by five methods, using the transmission data of the earth's atmosphere at 7 to 15  $\mu$ , published by Fowle in the Smithsonian Physical Tables. In the meantime, based upon observations at Flagstaff, Ariz. (elevation 7,250 ft.), Adel and Lampland have published atmosphere transmissions that appear to be somewhat different from the Smithsonian measurements, in the spectral band extending from 7 to 15  $\mu$ .

Since the planetary-radiation measurements were made at Flagstaff, the data obtained during the oppositions of Mars in 1924 and in 1926 have been recalculated, using the atmospheric transmissions observed at that station. In the present communication the five methods and procedures previously used, by three calculators, in deriving planetary temperatures are reviewed, and it is shown that in four of these methods of calculation, which employ the law of total radiation of a black body, there is but little difference in the planetary temperatures deduced by using the transmission coefficients of the earth's atmosphere published by these two sets of observers. This is owing to the fortuitous circumstance that, while they differ in spectral outline, there is but little difference in the total areas encompassed by these two transmission curves, and hence, in the calculated total amount of planetary radiation transmitted by the earth's atmosphere. Hence, no revision is made of the planetary temperatures previously deduced by the four methods involving the law of total radiation.

On the other hand, the fifth method, using the law of spectral radiation of a black body and the Flagstaff transmission coefficients of the atmosphere, gives planetary temperatures that are entirely different from the values previously deduced by this method, and by the four other methods, by applying the Smithsonian data. This



inconsistency can be eliminated, at least in part, and the data harmonized by taking into consideration selective emission of the planetary surface.

On the assumption that the surface of Mars, like that of the earth, is composed of silicates (feldspar, mica, silica, etc.) which have a high selective emission at 8 to 10  $\mu$ , the temperatures derived from the spectral components of planetary radiation of Mars, measured in 1926, are in good agreement with the values calculated by other methods that are less affected by selective spectral emission. From this it would appear that, assuming that the temperatures deduced by the other methods of calculation are indicative of meteorological conditions at the time of making the observations, the fluorite-filter method of analysis may be a useful means of securing information on the selective spectral emission of the planetary surface.

In a supplementary note a new thermocouple, made of bismuth and Chromel-P wires, suitable for planetary radiometry is described. 13 p. 5c.

RP1459. Tensile elastic properties of nickel, copper, open-hearth iron, and typical steels. Dunlap J. McAdam, Jr., and Russell W. Mebs.

From stress-set curves are derived proof stresses for five values of permanent set. From corrected stress-strain curves are derived values of the modulus at zero stress and its stress coefficient. The diagrams show the influence of prior plastic extension on these indices.

The curves of variation of the proof stresses with plastic extension are affected by the rate of work-hardening, by variation of internal stresses of two kinds, and by the rest interval. The curves of variation of the modulus of elasticity with plastic extension are affected by variation of crystal orientation, internal stress, and lattice expansion, and by rest. The curves of variation of the stress coefficients of the modulus are affected by all these factors except possibly the reorientation factor. 63 p. 15c.

RP1460. Soil-corrosion studies, 1939: Ferrous and nonferrous corrosion-resistant materials. Kirk H. Logan.

Since the beginning of the Bureau's soil-corrosion investigation in 1922, specimens of a wide variety of materials suggested for service underground have been exposed to various soil conditions and inspected at regular intervals. In this paper is reported the condition of the specimens of ferrous and nonferrous metals after underground exposures of from 2 to 17 years. Because of the variety of environmental conditions represented at the test sites, some idea of the corrosion resistance of the materials in most of the corrosive environments commonly encountered in soils can be obtained. Relations between corrodibility and chemical composition are indicated for certain classes of materials. 22 p. 10c.

RP1461. Some properties of the dry air-setting type of refractory bonding mortar. Raymond A. Heindl and William L. Pendergast.

Seventeen families of air-setting refractory mortars of the type marketed in the dry condition were investigated in the unheated state with regard to tempering water, fineness of grain, soluble alkali content, pyrometric-cone equivalent, suitability for troweling and dipping, drying and setting properties, and strength. After heat treatments at various final temperatures the strengths of the mortars were determined. In rupturing assemblages of two half-brick and mortar, the types of failures were noted. The tendency of the mortars to shrink, crack, and flow when exposed to high temperatures, both in fusion blocks and in units of three brick each, was also investigated.

The ingredients of the mortars were all fine-grained, only a small amount being retained on a No. 40 sieve. The strengths of the neat mortars covered a wide range; the strengths of those received and stored in metal drums indicated the desirability of storage in airtight containers. In a series of heat treatments the neat mortars in general were found to have the least strength when preheated at 750° C. However, the least strengths of the majority were noted in assemblages of brick and mortar preheated at 1,000° C. The mechanical troweling machine gave a better indication of the workability of the mortars than did the time-of-set test. Observations made on the mortars heated in fusion blocks in general corroborated the observations made of the shrinkage, cracking, and fusion of the same mortars heated in brick piers. 16 p. 15c.

RP1462. Creep rates of cold-drawn nickel-copper alloy (monel metal). John A. Bennett and Dunlap J. McAdam, Jr.

A description is given of new equipment recently assembled at this Bureau for testing the creep of metals.

The apparatus was used to study the creep rate of cold-drawn nickel-copper alloy over a wide range of stress and temperature. Each specimen was used for a series of tests, which allowed a more rapid determination of the characteristic creep rates than using a single specimen for each test. The data indicate that the characteristic creep



rate depends only on the stress and temperature, and is not affected by prior stresses or temperatures. The influence of stress on the rate of creep increases with increasing stress, while the influence of temperature on the rate of creep decreases with increasing temperature. The results of the tests are shown in graphs, as no mathematical expression was found which would represent them. 21 p. 10c.

RP1463. Frictional properties of rubber. Frank L. Roth, Raymond L. Driscoll, and William L. Holt.

Laboratory measurements of coefficients of friction of soft rubber compounds were made by towing specimens on horizontal tracks and by allowing them to slide down inclined tracks. The specimens were prepared by attaching the rubber to a metal backing and molding it against glass surfaces having different degrees of roughness. The coefficients increase markedly with speed, ranging from about 1 at  $10^{-4}$  cm/sec to more than 4 at 5 cm/sec. The occurrence of vibrations prevented observations at higher speeds. Static friction is greater than dynamic friction for speeds appreciably less than  $10^{-3}$  cm/sec and less than dynamic friction for greater speeds. The coefficients decrease slightly with increasing pressures and are independent of the size of the specimen. Except at very low speeds the smoother surfaces yield the higher coefficients. Materials such as talc or bloom on the sliding surfaces cause large decreases in the coefficients.

Attention is called to the dependence of the coefficients of friction on the speed, which is shown in several previous investigations on rubber and other materials. 24 p. 10c.

RP1464. The first spectrum of antimony. William F. Meggers and Curtis J. Humphreys.

The spectrum emitted by neutral antimony atoms has been photographed, measured, and analyzed. Measured wavelengths and estimated relative intensities are given for 466 lines, ranging from 1388.91 to 12466.75 Å in wavelength and from 1 to 2500 in intensity. Nearly 80 percent of these lines are classified as combinations of 60 even energy levels arising from  $5s^2 5p^2 ns$ ,  $5s^2 5p^2 nd$ , and  $5s 5p^4$  electron configurations and 31 odd levels from  $5s^2 5p^3$ ,  $5s^2 5p^2 np$ , and possibly  $5s^2 5p^2 nf$ . The average difference between observed and computed wave numbers is  $0.15 \text{ cm}^{-1}$ . A paucity of lines in the visible spectrum and intense radiation of antimony atoms in the ultraviolet and infrared are seen to be consequences of the relative values of various groups of levels. Although it is not possible to give a complete quantum interpretation of all the levels, several spectral series of the type  $5s^2 5p^3 - 5s^2 5p^2 ns$  are proposed, and an absolute value of  $69700 \text{ cm}^{-1}$  is deduced for the ground state,  $5s^2 5p^3 {}^4S_{3/2}$ , of neutral antimony atoms. From spectroscopic data, the principal ionization potential of antimony is calculated to be 8.64 volts. 16 p. 5c.

RP1465. Structural changes in the bonding layer of soft-soldered joints in copper pipe lines on long-continued heating. William H. Swanger and Arthur R. Maupin.

In the course of previous investigations to establish the merits of soldered joints in copper-tube lines for domestic plumbing and other purposes, it became evident that in the evaluation of such joints consideration must be given to possible deterioration with time of the bond of the soldered joint if the service involves use at elevated temperatures. Joints made with solder containing tin were found to be susceptible to such a change, under favorable circumstances, whereas many lead-base solders were not. By means of metallographic studies of specimens cut from soldered joints held at elevated temperature for long periods, the nature of the microstructural change was established and correlated with the lowering of the bonding properties of the soldered joint. Essentially, this consists in the formation of a bonding layer adjacent to the copper base by alloying, by diffusion of the tin of the solder and the adjacent copper. Microhardness determinations showed this constituent to be much harder than the initial solder and also harder than the copper base. Evidence of brittleness was also found. Most tin-free lead-base solders, including lead-silver solder, were found not to be susceptible of this change. Lead-cadmium solder was an exception. 9 p. 10c.

RP1466. Electrical conduction in the glass insulation of resistance thermometers. Harold J. Hoge.

At temperatures above  $350^\circ \text{C}$ , electrical conduction may become troublesome in the glass through which the leads of certain types of resistance thermometers are sealed. It was found that conduction in these seals is rapidly reduced by polarization of the glass, and that the error in temperature measurement resulting from conduction in the glass may be considerably reduced by adopting a measuring schedule which takes full advantage of this polarization.

One type of glass was investigated under experimental conditions which prevented polarization. At 445° C this glass had a volume resistivity of approximately 21,000 ohm-cm. The temperature dependence of the resistance could be represented very roughly by  $1/r = Ae^{-\epsilon/kT}$ , with  $\epsilon$  having a value of the order of 0.8 electron volt. 10 p. 5c.

RP1467. Tensile and compressive properties of some stainless-steel sheets. C. S. Aitchison, Walter Ramberg, L. B. Tuckerman, Herbert L. Whittemore.

Tensile and compressive tests were made on specimens from chromium-nickel (17-7 and 18-7) stainless-steel sheets, with cold-reductions from zero percent (annealed) to 50 percent, and thicknesses from 0.01 to 0.06 in. The tensile yield strengths ranged from 34 to 200 kips/in<sup>2</sup>. The effect of a stress-relieving treatment at 300° C for 24 hours was investigated for one of the compositions.

The tensile tests were made on standard specimens. The compressive tests were made by the pack method developed at the National Bureau of Standards and by the cylinder method developed by Russell Franks of the Union Carbide & Carbon Research Laboratories. Tests were made on both longitudinal and transverse specimens from each sheet.

The results are given in tables and stress-strain curves to facilitate application in the design of light-weight structures from these materials. The effect of the degree of cold-reduction and of the stress-relieving treatment on the shape of the stress-strain curves and on the tensile and compressive properties is discussed. 69 p. 15c.

RP1468. Elimination of oxide films on ferrous materials by heating in vacuum. Vernon C. F. Holm.

An investigation of the mechanism by which lightly oxidized specimens of ferrous materials were brightened when heated in vacuum showed that the presence of carbon was essential. Oxidized specimens of iron containing small amounts of carbon were brightened in 15 to 20 minutes at 800° C and the elimination of the oxide film was accompanied by decreases in the carbon content. Cleanup of oxide films on stainless steel occurred also when the specimens were heated to about 1,050° C. Oxidized high-purity iron which contained less than 0.001 percent of carbon could not be brightened by vacuum heating at temperatures up to 1,250° C. Vacuum heating of lightly oxidized specimens of high-purity iron sometimes caused the oxide film to agglomerate, forming distinct, geometric patterns that could be observed under the microscope. 11 p. 10c.

RP1469. Measurements of ultraviolet solar- and sky-radiation intensities in high latitudes. W. W. Coblentz, F. R. Gracely, and R. Stair.

Data are given on the intensity of the biologically effective ultraviolet radiation, of wavelengths 3200 Å and shorter, from the sun and the entire sky, incident on a horizontal plane, under various meteorological conditions, in high latitudes. These data were secured by means of a photoelectric cell and automatic recording apparatus, whereby a continuous record of ultraviolet intensities, in absolute value, was obtained during the voyage of the Louise A. Boyd Arctic Expedition, up the west coast of Greenland to Etah (lat. 78.3° N) and down the coast of Baffin Land and Labrador.

The outstanding results of this survey are, that, for the same solar heights, in the highest latitudes visited (78° N) the ultraviolet intensities appear to be somewhat higher than in latitude 62° N, but somewhat lower than in latitude 39° N (Washington), in agreement with expectation, taking into consideration the distribution of ozone in the stratosphere with latitude and the season. In the highest latitudes, at the noon hour, on the clearest days, in mid-summer, the intensity of the ultraviolet solar and sky radiation ranged from 30 to 40  $\mu\text{w}/\text{cm}^2$ , which is a significant value biologically, of especial interest to the medical profession in connection with the question of the incidence of rickets. 11 p. 10c.

RP1470. Rate of oxidation of typical nonferrous metals as determined by interference colors of oxide films. Dunlap J. McAdam, Jr. and Glenn W. Geil.

By means of interference colors the rates of oxidation were determined for 18 nonferrous metals and were compared with those for typical steels. The influence of temperature, oxidation time, and film thickness on the rate of oxidation is illustrated by projections of surface in three-dimensional diagrams. The diagrams for the nonferrous metals are similar to those for steels. For a constant film thickness, the relation between temperature and oxidation time is linear logarithmic. The variation of film thickness with either temperature or oxidation time, plotted logarithmically, is represented by a reversed curve. A discussion is given of the influence of the affinity of the metal for oxygen and of the rate of diffusion through the oxide film. The film



behaves as if the specific resistance varies nonlinearly with the film thickness. 43 p. 10c.

RP1471. Improved instrument for measuring the air permeability of fabrics. Herbert F. Schiefer and Paul M. Boyland.

This paper describes a new model of an instrument for the direct measurement of the air permeability of fabrics. The air, which is drawn through the fabric by a given suction, is measured with orifice-type flowmeters. The instrument is mounted in the top of a table and a new clamping device is provided, which permit measurements to be made rapidly on any part of a large piece of cloth without cutting.

The calibration and operation of the instrument are discussed. Results of measurements on two very different types of fabrics — parachute cloth and blankets — are given for several methods of clamping. A suitable method is described for which the edge leakage is negligible. The random sampling error of the average of 5 tests for air permeability is less than 5 percent, approximately 9 times out of 10. 6 p. 10c.

RP1472. Properties of high-purity iron. Harold E. Cleaves and John M. Hiegel.

Results are recorded of new determinations of the workability, microstructure, density, and the thermal, mechanical, electrical, and magnetic properties of high-purity iron, in which the maximum amount of an individual impurity was 0.004 percent and the total of impurities in any specimen was 0.01 percent or less. 25 p. 10c.

RP1473. Perforated cover plates for steel columns: Program and test methods. Ambrose H. Stang and Martin Greenspan.

Tests were made to determine the mechanical properties of perforated cover plates intended to be used as a substitute for lattice bars or batten plates in built-up box-type columns. Each test column was built up from one perforated plate and either two or four angles. Columns with unperforated plates were used as controls.

In this paper the program is outlined and the methods of test are described. The results of the tests and the conclusions will be presented in subsequent papers. 18 p. 10c.

RP1474. Perforated cover plates for steel columns: Compressive properties of plates having ovaloid perforations and a width-to-thickness ratio of 40. Ambrose H. Stang and Martin Greenspan.

Tests were made to determine the mechanical properties of perforated cover plates intended to be used as a substitute for lattice bars or batten plates in built-up box-type columns. Each test column was built up from one perforated plate and either two or four angles. Columns with unperforated plates were used as controls.

This paper gives the results of the tests on columns having plates of three different perforation spacings.

It was found that the perforated plates contributed to the strength, and especially to the stiffness, of the columns, and that the factor of stress concentration, due to the presence of the perforations, varied from 2 to 2.5 based on the gross area (1.8 to 2.1 based on the net area). 26 p. 10c.

RP1475. Effect of altitude on knock rating in CFR engines. Donald B. Brooks.

Knock ratings made at altitude have shown systematic differences from ratings made at sea level, on some fuel types. Altitude-chamber tests showed that complete agreement could be obtained if tests were made at uniform knock intensity, and that uniform knock intensity was obtained when the cylinder clearance volume was reduced in linear relation to air pressure. From these tests, equations are developed to relate clearance volume for standard knock intensity to air pressure and to octane number for the ASTM Motor and the CFR Research Methods of knock rating. Equations are also developed to relate octane-number requirement to air pressure, and these are shown to agree with road-test data. 22 p. 10c.

RP1476. Weather resistance of porcelain-enameled iron structural units. William N. Harrison and Dwight G. Moore.

A study of the weathering resistance of vitreous enameled architectural panels was begun by the National Bureau of Standards in 1939. The study involves 864 one-foot-square panels, representing 14 types of enamel and a like number of 4- by 6-in. laboratory specimens. At the end of the first year of exposure at four locations selected for different climatic conditions, over half of the panels showed no visible weathering effect, and in no case did weathering produce any failure of the enamel to protect the underlying metal from rusting.

The full-mat enamels were found unsuited for architectural use where appearance is important, because of fading and of difficulty in cleaning. Mild fading, found on



some of the non-acid-resistant colored enamels, was associated with a minute pitting of the enamel surface, probably caused by the presence of acid-forming gases in the atmosphere. The enamels of high acid resistance did not show this effect.

Weathering of the panels was found to be more pronounced at those locations where there is a relatively high concentration of combustion gases, and less severe where there is a practical absence of these gases in the atmosphere. An accelerated weathering test is described, which gives an effect closely resembling the most important form of actual weathering. 20 p. 10c.

RP1477. Relief of residual stress in streamline tierods. Rolla E. Pollard and Fred M. Reinhart.

About two-thirds of the residual stress in cold-worked SAE 1050 steel tierods was relieved by heating them 30 minutes at 600° F. Cold-worked austenitic stainless steel tierods could be heated at temperatures up to 1,000° F without lowering the important physical properties. With materials of straight 18-8 composition, however, the limiting heating temperature was found to be about 900° F, because at higher temperatures precipitation of chromium carbide occurred. It is possible that materials containing additions of titanium, columbium, or molybdenum could be heated at higher temperatures, since the carbides of these elements would be precipitated in preference to chromium carbide.

Microscopic examination and Vickers indentation tests indicated localized differences in the amount of cold-working. Such differences may explain the distribution of residual stress in cold-worked tierods. 18 p. 10c.

RP1478. Measurement of the fading rate of paints. Arnold J. Eickhoff and Richard S. Hunter.

Ability to resist fading is a valued property of most paint and textile materials, and therefore improved methods for measuring the course of fading are in demand. Two of the important evidences of the fading of paints, namely change of color and change of gloss, can be measured rapidly by photoelectric methods developed within the past few years. In the present study photoelectric tristimulus measurements of color change and photoelectric measurements of specular-gloss change were used to follow the fading of several paint samples exposed both to outdoor weather and to two machine treatments (*A* and *B*) designed to weather the samples at an accelerated rate. With these measurements it was possible to compare numerically the rates of artificial and natural fading of the paints. The data which were obtained show: (1) the treatment used in conjunction with apparatus *A* caused fading which averaged 20 times as fast as fading outdoors, but the speed-up factor varied from roughly 5 times for one paint to roughly 40 times for another; (2) the treatment used in conjunction with apparatus *B* caused fading which averaged 5 times as fast as fading outdoors, but the speed-up factor varied from roughly 3 times for one paint to roughly 20 times for another; and (3) for almost every paint tested the factor relating the speed of fading from treatment in apparatus *A* to the speed outdoors was more nearly constant through the whole fading process than the corresponding factor for treatment in apparatus *B*. Thus treatment *A* not only faded paints faster, but it provided a preview of the course of fading which was usually a better representation of outdoor fading than that provided by treatment *B*. The data collected during the present study are noteworthy chiefly for the methods they demonstrate. These should be valuable for future studies of the fading of materials and for the examination of methods for accelerating fading. 21 p.

RP1479. Determination of carbon and hydrogen in bone black and other chars. Victor R. Deitz and Leland F. Gleysteen.

The carbon and hydrogen contents of samples of bone chars, charcoals, and vegetable carbons are determined by combustion in oxygen, the resultant carbon dioxide and water being weighed. The procedure for the handling of such highly adsorptive substances is set forth with a description of the necessary apparatus.

A simple procedure is adopted to bring each sample for analysis to a constant weight. This consists in exposure of the sample to air saturated with water in an exsiccator for 18 hours, and subsequent heating in a helium atmosphere at 105° C for 18 hours. In the determination of the carbon, corrections are made for the carbonate remaining in the ash from the combustion and for the carbonate and the adsorbed carbon dioxide contained in the original sample.

The results are tabulated to give these separate contributions to the total carbon. A comparison is made with the results for the same materials obtained by the deter-

mination of the loss upon ignition of the acid-washed residue of each sample. 11 p. 5c.

Title page and contents for volume 28. 6 p. 5c.

RESEARCH PAPERS FROM JOURNAL OF RESEARCH OF THE NATIONAL BUREAU OF  
STANDARDS, VOLUME 29, JULY—DECEMBER 1942

RP1480. A new determination of the constant of gravitation. Paul R. Heyl and Peter Chrzanowski.

A new determination of the constant of gravitation by means of the torsion balance has been made in the hope of improving the precision of the result published in 1930. A number of suggested improvements in the apparatus were tried, and two of these were adopted. The result obtained shows so slight an improvement over the 1930 result that it appears that the limiting point of diminishing returns has been reached with this form of apparatus. 31 p. 10c.

RP1481. Influence of initial structure and rate of heating on the austenitic grain size of 0.5-percent-carbon steels and iron-carbon alloy. Thomas G. Digges and Samuel J. Rosenberg.

Tests were made to determine the influence of variations in initial structure and rate of heating through the transformation temperature range on the grain sizes at 1,475° and 1,600° F of a high-purity alloy of iron and carbon and two commercial steels each containing 0.5 percent of carbon. Variations in initial structure had no effect on the grain size of the iron-carbon alloy. Although the initial structure had some influence on the grain size of the steels, no correlation was found between the grain size and the spacing of pearlite or the form and distribution of the carbides. The rate of heating had a pronounced effect on the grain size of the iron-carbon alloy, and in some cases the rate of heating also influenced the grain size of the steels. However, the trend in the steels was the reverse of that of the iron-carbon alloy in that the finest grains were obtained in the steels with slow rates of heating. 8 p. 15c.

RP1482. Microscopic structure of flax and related bast fibers. Charles W. Hock.

The microscopic structure of flax and of related bast fibers was investigated. The stem of the flax plant consists of two main parts, a central woody core, and a surrounding cortex which contains the bast fibers. The cambium layer lies between these regions. Retting involves, essentially, a softening of the tissues to permit separation of the fibers from the other parts of the stem. The cambium layer is attacked first during this treatment, followed later by attack on other thin-walled cells in the cortex.

Flax and related bast fibers, such as hemp, jute, and ramie, have a similar origin and structure. They are obtained from the stem in the form of long filaments, each of which is made up of cells. In this respect they differ from cotton fibers, which are single plant cells.

A flax cell has a primary and a secondary wall. The former constitutes the surface of each cell and consists largely of wax and other material, much of which has generally been assumed to be of a pectic nature. The secondary wall, which comprises the bulk of the fiber, is made up of innumerable cellulose fibrils, the outermost layer of which winds in one direction, whereas the majority of the fibrils beneath this layer wind in the opposite direction. These fibrils are grouped so as to give the wall a lamellar pattern. There is a greater number of these layers in the walls of the cells at the base of the stem than in the cells from the growing tip. A corresponding increase in thickness of the wall, from the tip of the stem where the cells originate to the base where they mature, also prevails. All the bast fibers have essentially similar structures. Flax and ramie, however, differ from hemp and jute in the directions of fibrillate orientation, and this accounts for some of the differences in the physical properties of the two groups. 10 p. 10c.

RP1483. Accelerated aging of lace leathers. Joseph R. Kanagy and Philip E. Tobias.

Alum-, indian-, and chrome-tanned lace leathers, submitted by various manufacturers, were tested for deterioration under accelerated-aging conditions. In addition, the physical and chemical properties of these leathers were determined according to the tests prescribed by the Federal specification for lace leathers. The alum-tanned lace leathers were much less stable under the conditions of accelerated aging than the indian- and chrome-tanned leathers. Several types of chrome-tanned leathers, including chrome-tanned lace leather, showed intermediate stability. From the results of these tests, it appears that measurements of physical properties, such as strength, stretch, and flexibility, together with an accelerated-aging test, may be expected to give more valuable information about the performance characteristics of lace leathers than the measurements required by the present Federal specification. 6 p. 5c.



RP1484. Effect of moderate cold-rolling on the hardness of the surface layer of 0.34-percent-carbon steel plates. Harry K. Herschman.

The influence of moderate cold-rolling on the surface indentation hardness of 0.34-percent-carbon steel plate initially surface-finished by three different methods was investigated. Variations of the hardness of the surface layers extending to different depths below the surface of the specimens were determined by applying different loads on a Knoop indenter. Indentation hardness tests also were made with the Rockwell Superficial hardness machine. The results obtained with the Knoop indenter showed significantly lower hardness numbers for the superficial layer of the steel after the lighter degrees of rolling, the magnitude of change apparently being influenced by the mode of initial finishing. Hardness decreases were not revealed by tests made with the Rockwell Superficial machine nor in any case in which the penetration of the Knoop indenter exceeded about 0.0003 inch. 11 p. 10c.

RP1485. Note on flexural fatigue of textiles. Herbert F. Schiefer and Paul M. Boyland.

Results are given which indicate that the ability of a textile fabric to withstand repeated flexing depends upon the structure of the fabric, the position and structure of the yarn in the fabric, and the kind of fiber from which the fabric is made. 3 p. 10c.

RP1486. Elasticity of wool as related to its chemical structure. Milton Harris, Louis R. Mizell, and Lyman Fournet.

Wool protein, like other fibrous proteins, is composed of long, flexible molecular chains. This flexibility appears to be the basis of the "long-range" elasticity of wool fibers. The wool fiber is distinguished from other textile fibers by the presence of covalent disulfide cross-links between these main chains. Rupture of these links by chemical means decreases the strength of the fiber without necessarily affecting the elastic recovery. Rebuilding the covalent linkages largely restores the original properties of the fiber.

Wool appears to be analogous to rubber in several respects. Thus the stress-strain, solubility, and swelling characteristics are greatly influenced by the extent of cross-linking in the two materials. 14 p. 5c.

RP1487. Specific heat of the synthetic rubber Hycar O. R. from 15° to 340° K. Norman Bekkedahl and Russell B. Scott.

Measurements of specific heat were made on a sample of Hycar O. R. synthetic rubber from 15° to 340° K by means of an adiabatic vacuum-type calorimeter. The experimental values of the specific heat between 15° and 22° K were well represented by the Debye specific-heat equation, using a  $\beta v$  value of 80, and accordingly the values below 15° K were calculated with this equation. At about 250° K the material has a transition of the second order, the specific heat increasing by about 40 percent to a value of 1.84 int. joule-gram<sup>-1</sup>-degree<sup>-1</sup> just above the transition. From 250° to 340° K the specific heat-temperature curve is nearly linear, and the values can be calculated to within 0.2 percent from the formula  $C_p = 0.00283T + 1.126$ , in int. joules-gram<sup>-1</sup>-degree<sup>-1</sup>. At 298.16° K (25° C) the specific heat is 1.971 int. joules-gram<sup>-1</sup>-degree<sup>-1</sup> (0.4712 calories-gram<sup>-1</sup>-degree<sup>-1</sup>). The increase in entropy resulting from heating from 0° to 298.16° K was calculated to be  $1.743 \pm 0.002$  int. joules-gram<sup>-1</sup>-degree<sup>-1</sup> (0.4167  $\pm 0.0005$  calories-gram<sup>-1</sup>-degree<sup>-1</sup>). 9 p. 5c.

RP1488. Equation of motion for the steady mean flow of water in open channels. Garbis H. Keulegan.

There is disagreement in the literature regarding the use of the Coriolis and the Boussinesq velocity-distribution coefficients in the open-channel flow equation. It is shown in this paper that the use of either coefficient is correct, provided the terms representing the effects of resistance are properly interpreted. The methods of deriving the two forms of the flow equation are given in detail, and it is shown that in the form of equation containing the Boussinesq coefficient, the friction coefficient is related directly to the wall friction. In the form of equation containing the Coriolis coefficient, the friction coefficient is related to the rate of energy loss in the water. This has a direct bearing on the correct use of Manning's "n" in the equation of flow in open channels. 15 p. 10c.

RP1489. Metallographic study of the formation of austenite from aggregates of ferrite and cementite in an iron-carbon alloy of 0.5 percent carbon. Thomas G. Digges and Samuel J. Rosenberg.

The formation of austenite on heating aggregates of ferrite and cementite in a high-purity alloy of iron and carbon (0.50 percent carbon) is described. In fine pearlite,



austenite was preferentially nucleated at the interfaces of ferrite and carbide at the boundaries of pearlite colonies and proeutectoid ferrite or at the boundaries between pearlite colonies, although it occasionally formed within the colonies. In spheroidized structures, nucleation occurred at ferrite-carbide interfaces at the cementite network or at isolated cementite particles. Austenite formed at numerous interfaces, so that in the initial stages it was always *fine-grained*. However, if the rate of heating is slow, rapid grain growth takes place in the  $Ac^1$ - $Ac^3$  temperature range. The predominant factor in establishing the austenite grain size in this alloy was the rate of growth and not the rate of nucleation. 9 p. 10c.

RP1490. Fractionation of cellulose acetate. Arnold M. Sookne, Henry A. Rutherford, H. Mark, and Milton Harris.

By means of a series of three successive fractional precipitations, a solution containing 2 kg of commercial cellulose acetate was separated into 15 fractions varying in degree of polymerization from 30 to 380. The procedure involved the fractional precipitation of the acetate from a solution in acetone, using ethyl alcohol as the precipitant.

From the viscometrically estimated chain-lengths of the fractions, the distribution of chain-lengths in the starting material (excepting the first fraction) was obtained. The first fraction was not completely soluble in acetone or Methyl Cellosolve, and therefore no estimate of its degree of polymerization was obtained. It was shown that a large proportion of the ash and haze-producing materials are contained in this first fraction. All of the other fractions have very low ash contents, and with the exception of the fractions of very low degrees of polymerization, the acetyl contents are constant. A phase diagram showing some of the solubility relationships of the starting material and several of the fractions is given. 8 p. 5c.

RP1491. Oxidation of cellulose: the reaction of cellulose with periodic acid. Henry A. Rutherford, Francis W. Minor, Albert R. Martin, and Milton Harris.

An investigation has been made of the mode of attack of cellulose by periodic acid during the early stages of the oxidation (that is, oxidation of approximately 1 percent of the glucose residues). Under these conditions, it is shown that the reaction is confined to oxidation of the secondary hydroxyl groups to aldehyde groups, and results in a rupture in the carbon chain between carbon atoms 2 and 3 of the glucose unit. In accordance with this mechanism it is shown that two moles of aldehyde groups are produced for each mole of oxidant consumed. The aldehyde groups of the periodic acid-oxycellulose can readily be converted to carboxyl groups, titration of which provides an independent check on the content of the former.

Periodic acid-oxycellulose is characterized by its susceptibility to further attack by alkaline solutions. The alkali-sensitivity of these materials, as measured by solubility in hot dilute sodium hydroxide and by cuprammonium fluidity, appears to be proportional to the content of aldehyde groups. However, upon conversion of all of the aldehyde groups to carboxyl groups, the alkali-lability practically disappears. The results suggest that the sensitivity of periodic acid-oxycellulose to alkali does not depend solely on the rupture of the glucose ring between carbon atoms 2 and 3, but is related to the specific instability toward alkali of the dialdehyde formed during the oxidation. 11 p. 5c.

RP1492. A flow manostat for various purposes, including the candy test. Max J. Proffitt.

The flow manostat described in this paper is virtually a sensitive pressure-reducer in which the valve unit consists of a knife-edged circular orifice which is converted into an annular opening by means of a coaxial tapered core that floats upon a liquid surface which is depressed through contact with the gas at the regulated reduced pressure. Any change in the regulated pressure produces an axial movement of the core, thus expanding or contracting the area of the annular opening by an amount which is just sufficient to compensate approximately the effects of the change in the service pressure that induced the change in the regulated pressure. To minimize friction, the major diameter of the spindle or tapered part of the core is made slightly less than the diameter of the orifice. This allows the spindle to move its full length through the orifice without touching the edges of the orifice. Each valve unit has only a short range of variability in throughput capacity. Any reasonable capacity outside of this range can be obtained by substituting a valve unit of appropriate size in the same manostat. Each valve unit comprises an orifice plate with knife-edged opening (or else a pair of such plates), together with a properly fitting core having one spindle or two as required. The volume of flow always is governed by the discharge characteristics of the nozzle or fixed group of simultaneously operating nozzles served by the manostat. Any change in these characteristics will involve readjustment of the regulated pressure.

An experimental manostat equipped with a double, self-balancing valve unit conforming approximately with this design reduced a gas service pressure varying between the limits of 104 and 164 mm of water to a regulated pressure of  $49.6 \pm 0.5$  mm of water, while serving three burners consuming a total of about 8 cubic feet of gas per hour. 13 p. 10c.

RP1493. An equation for the isotherms of pure substances at their critical temperatures. Cyril H. Meyers.

An empirical equation is presented for data along the isotherms of pure substances at their critical temperatures and densities up to 1.1 times the critical density. The equation has five constants in addition to the universal gas constant. Of these five one is limited to a single value, if a simple solution to the equation is to be obtained; three are determined by the critical conditions; and the remaining constant is determined empirically from data other than those for the critical state. Three of the five constants are independent of the substance, one is an explicit function of  $RT_c/p_cV_c$ , whereas the reciprocal of the fifth is found to be practically a linear function of  $RT_c/p_cV_c$  for values of that ratio up to 3.8 or 3.9. This relation correlates the isotherms for various substances, so that data on two well-chosen substances, such as hydrogen and carbon dioxide, suffice to determine the fifth constant and consequently the critical isotherm for other substances, for which  $RT_c/p_cV_c$  is not greater than 3.8. For substances such as ammonia (for which  $RT_c/p_cV_c$  is 4.08), the fifth constant may not conform to the linear relation.

The equation represents the data for 12 of 13 substances within the experimental error, the exceptional substance being water (for which  $RT_c/p_cV_c$  is 4.34).

At low densities the equation reduces to a simpler form which expresses  $pV/RT$  as a quadratic function of density.

The fugacity along the critical isotherm can be calculated from the equation. The fugacity at the critical state is approximately two-thirds the critical pressure for all substances. The fugacity of  $\text{CO}_2$  is calculated at 1 atmosphere and at the critical pressure. 20 p. 10c.

RP1494. X-ray measurement of the thickness of the cold-worked surface layer resulting from metallographic polishing. Herbert C. Vacher.

Different thicknesses of cold-worked layers, each representative of a specific abrasive treatment used in metallographic polishing, were produced on annealed specimens of steel (0.34% C), copper, and aluminum. The back-reflection patterns of the specimens showed a progressive increase in the degree of diffuseness with thickness in the range from 2 to 25 microns on the steel specimens, 2 to 42 microns on the copper specimens, and 5 to 95 microns on the aluminum specimens. A comparison of these patterns with others obtained from copper and steel specimens indicated that the cold-worked layers produced by certain fine-abrasive treatments were thicker than those produced by certain coarse-abrasive treatments. 5 p. 10c.

RP1495. Provisional pH values for certain standard buffer solutions. Roger G. Bates, Walter J. Hamer, George G. Manov, and S. F. Acree.

For use in the calibration of electrometric pH assemblies, 17 standard buffer solutions have been investigated, and pH values at 20°, 25°, and 30° C have been assigned to them. The pH values of these solutions range from 2.27 to 11.68 and are considered accurate to  $\pm 0.02$  pH unit.

Hydrogen-silver-chloride cells without liquid junctions were used for establishing the precise pH values of the buffer mixtures. The assumptions made to determine the activity coefficients of the ions in the mixtures are discussed. The method of assigning an accurate pH value to a buffer mixture is outlined.

Directions for preparing the mixtures from purified anhydrous salts, standard solutions of acid and alkali, and pure water are given. Changes of temperature have a large effect on the pH values of the buffers of pH greater than 7 than on those of the acid buffers. In all cases the effect of dilution is small; an error of 1 percent in the volume of solvent added results in a change of less than 0.001 pH unit.

The use of a pH meter of the glass-electrode-calomel-electrode type calibrated by means of a standard buffer may often involve greater uncertainties than those inherent in the pH value assigned to the buffer mixture. It should be recognized that errors arising from liquid junction, hysteresis, temperature, and salt effects may combine to give an uncertainty of 0.01 and 0.03 unit or more in practical pH tests. 8 p.

RP1496. Surface available to nitrogen on bone black and other carbonaceous adsorbents. Victor R. Deitz and Leland F. Gleysteen.

The adsorption of nitrogen was determined at liquid nitrogen and liquid oxygen temperatures by measuring the pressure decrease of a known volume of the gas



exposed to each of 20 different samples of bone blacks, activated carbons, vegetable carbons, and coconut charcoals. Typical adsorption isotherms of these data are illustrated. Specific surfaces were estimated with fair accuracy from an analysis of the data with the aid of the multimolecular theory of adsorption. The surfaces of new bone chars, service bone chars, and spent bone chars are compared; the ratio of the specific surface of a new char to that of a spent char may be as great as 7. The distribution of pore sizes in the adsorbents is discussed and the data are divided into five groups, each characterized by a value of  $n$ , which is defined as the maximum number of adsorbed layers possible on the surface of the material. All the samples in each group have a common isotherm when reduced to unit surface. The differential heats of adsorption are also determined from the data. The adsorption at 77°K is also considered from the standpoint of capillary condensation. The volume, as adsorbed liquid nitrogen, is plotted against the corresponding radius of a cylindrical capillary, which is determined from the Kelvin equation. 35 p. 10c.

RP1497. Preparation of lower aldonic acids by oxidation of sugars in alkaline solution. Horace S. Isbell.

Directions are given for the preparation of *l*-erythronic, *d*-threonic, *d*-lyxonic, *l*-zylonic, and *d*-arabonic acids by means of oxidation with oxygen of certain sugars in alkaline solution. *d*-Arabonic acid was obtained in about 70-percent yield, in agreement with the results of prior investigators. Lower yields were obtained for other aldonic acids, and they do not differ greatly from those obtained by oxidation with air. Nevertheless, the simplicity of the method makes it suitable for the production of lower aldonic acids by persons requiring a supply of these scarce materials. *l*-Erythronic and *d*-threonic acids were separated in the form of brucine salts, the optical rotations of which were found to be represented by the following expressions:  $[\alpha]^{20}_D = -28.4 - 0.85C + 0.025C^2$ , in which  $C$  is the grams of anhydrous brucine *d*-erythronate in 100 ml of aqueous solution;  $[\alpha]^{20}_D = -28.5 - 0.9C + 0.025C^2$ , in which  $C$  is the grams of anhydrous brucine *d*-threonate in 100 ml of aqueous solution. 6 p. 5c.

RP1498. Characteristics of wide-angle airplane-camera lenses. Francis E. Washer.

The relative illumination in the focal plane was measured for a number of wide-angle airplane-camera lenses, using a method depending upon the determination of the light-transmitting area of the lens effective at definite orientations of the lens. A new factor dependent on the lens design was found to be operative in reducing the values of the relative illumination in the unvignetted portion of the field for certain types of lenses. Determinations of the resolving power were also made and showed considerable variation in performance with type of lens. The effect of basing the distortion values upon the calibrated focal length instead of the equivalent focal length was determined. 14 p. 5c.

RP1499. Heat of combustion of benzoic acid, with special reference to the standardization of bomb calorimeters. Ralph S. Jessup.

New measurements yielded the value  $26428.4 \pm 2.6$  international joules per gram mass for the heat of combustion,  $Q_B$ , of benzoic acid at 25° C under the conditions of the standard bomb process. The difference, 0.036 percent, between the above value and that reported in 1934 is due to five factors: (1) An error in the previous value, resulting from the effect of dissolved carbon dioxide on the determination of the nitric acid formed in the bomb, (2) a change in the value used for the energy of formation of nitric acid in the bomb, (3) taking account in the present work (in the calculation of the value of  $Q_B$  at 25° from the observed value at 30°) of the temperature dependence of the Washburn reduction, (4) a change in the value used for the temperature coefficient of heat of combustion, arising from the use of a new value for the specific heat of benzoic acid, and (5) a small difference in the results of the calorimetric measurements. The 1934 results, when corrected for the first four of the above effects, are in agreement within 0.01 percent with the results of the present measurements. The procedure for correcting the results of calibration experiments originally calculated on the basis of the 1934 value of  $Q_B$  is described.

With one exception, values of  $Q_B$  at 25° C calculated from the results of previous measurements are in satisfactory agreement with the value given above.

When the amount of benzoic acid burned in each experiment was calculated from the mass of carbon dioxide formed, the present measurements yield the value  $3226.39 \pm 0.32$  international kilojoules per mole for  $-\Delta H^\circ_{298.16}$ , the decrease in heat content for the combustion reaction at 25° C when each of the gases involved in the reaction is in the thermodynamic state of the unit fugacity and the water formed in combustion is in the liquid state. 24 p. 10c.



RP1500. Dependence of the indigestibility of wool protein upon its polymeric structure. Walton B. Geiger and Milton Harris.

The resistance of wool to digestion by enzymes is probably due to a unique structure, consisting of peptide chains joined by disulfide cross-links to form a three-dimensional polymeric network of extremely high molecular weight. This conclusion is substantiated by a study of a series of derived wool proteins similar in composition but expected to differ in molecular weight. The proteins were prepared by first "depolymerizing" wool by reducing its disulfide cross-links to sulfhydryl groups, then making a series of solutions of this protein of widely varying concentration, and finally rebuilding the disulfide cross-links by reoxidation.

An investigation of the rates of digestion by pepsin of a series of such proteins showed that those preparations expected to be of low molecular weight were rapidly digested, whereas those expected to be of greatest molecular weight were almost as resistant to digestion as untreated wool. 7 p. 5c.

RP1501. Perforated cover plates for steel columns: Compressive properties of plates having ovaloid perforations and a width-to-thickness ratio of 68. Am-brose H. Stang and Martin Greenspan.

Tests were made to determine the mechanical properties of perforated cover plates intended to be used as a substitute for lattice bars or batten plates in built-up box-type columns. Each column was built up from one perforated plate and either two or four angles. Columns with unperforated plates were used as controls.

This paper gives the results of the tests on columns having plates of three different perforation spacings. The plates had ovaloid perforations and a width-to-thickness ratio of 68.

It was found that the perforated plates contributed to the strength and to the stiffness of the columns. The factor of stress concentration, due to the perforations, varied from 2 to 2.6 based on the gross area (1.7 to 2.1 based on the net area). 24 p. 10c.

RP1502. A reexamination of the Potsdam absolute determination of gravity. Hugh L. Dryden.

Recent absolute determinations of the acceleration of gravity differ from the generally accepted Potsdam value by amounts considerably greater than the probable error assigned to that value by the Potsdam investigators. The discrepancy is due in large part to an adjustment made with the intent of correcting for certain systematic errors. The adjustment was probably not warranted. If this adjustment is not made, the Potsdam result is about 12 parts per million less than the commonly accepted value as compared with 14 and 20 parts per million less as found in the recent absolute determinations. The best value of  $g$  for general use when accurate absolute values are needed is probably obtained by reducing the local value in the Potsdam system by about 15 parts per million. The Subcommittee on Gravity of the National Research Council Committee on Fundamental Physical Constants has recommended a reduction of 17 parts per million. 12 p. 5c.

RP1503. Catalyzed hydrolysis of amide and peptide bonds in proteins. Jacinto Steinhardt and Charles H. Fugitt.

The rates of hydrolysis by dilute acids of both a dissolved protein (egg albumin) and an insoluble protein (wool) are shown to depend not only on the temperature and acidity but also on the acid used. When hydrolyzed at 65° C by certain strong monobasic acids of high molecular weight, the amide and the peptide bonds are broken over 100 times as fast as when they are hydrolyzed with hydrochloric acid. Even among the common mineral acids, large differences appear. These differences in hydrolytic effectiveness parallel differences in the affinities of the anions of the acids for protein. A further reason for attributing this effect to the anions is the attainment, with anions of high affinity, of a maximum rate of amide hydrolysis at relatively low concentrations, stoichiometrically equivalent to the sum of the amino plus the amide groups. A similar limiting anion concentration or maximum rate of hydrolysis of the much more numerous peptide groups is not observed. On the basis of details of the dependence of the rate of hydrolysis on concentration of effective anions and hydrogen ions, a mechanism which involves combination of the groups hydrolyzed with hydrogen ions, is proposed.

At low concentrations of effective anions, amide hydrolysis is catalyzed more strongly than peptide hydrolysis. By keeping the concentration slightly below stoichiometric equivalence to the sum of the amino plus amide groups the amide groups may be rapidly hydrolyzed without extensive hydrolysis of the peptide bonds in the protein. Practical applications are suggested. 13 p. 5c.

RP1504. Fresnel reflection of diffusely incident light. Deane B. Judd.

The reflection factor of a plane boundary between two media has been computed by the Fresnel formula for unpolarized, perfectly diffused incident light as a function of the relative index of refraction of the media. Because of total internal reflection, the factors depend importantly upon whether the diffuse flux is incident externally or internally. For example, diffuse light in air incident on the plane surface of glass of index 1.5 is 9.2 percent reflected; but if the perfectly diffuse light is incident internally, the reflection factor is 60 percent. 4 p. 5c.

RP1505. Wear testing of carpets. Herbert F. Schiefer.

The NBS and Shawmut machines for testing the wear resistance of carpets, a gage for measuring the thickness of carpets, and an instrument for measuring the length of a tuft of pile from a carpet are described. The effects of the height of the vacuum-cleaner nozzle above the pile, the amount of suction at the nozzle, and the relative humidity and temperature of the air in which the test is made, on the results obtained with the NBS machine were studied. The effect of systematic changes in carpet construction on the wear resistance was investigated with each machine and under severe service conditions. Tests on 24 carpets of Axminster, velvet, and Wilton weaves were made on the two types of machines in several laboratories, and the results obtained in the different laboratories were correlated with each other and also with the results of 3 years of service tests on the same carpets. The correlations were highly significant, but large systematic differences between the weaves and between the laboratories were obtained. The latter difference is attributed primarily to a lack of uniformity in the testing procedures. Three types of vacuum-cleaning systems were used during the service tests, and their effect on the wear of the carpets and the effectiveness of cleaning were observed. The *S* index, which is the time required to wear the pile of a carpet down to one-fourth of the matted pile thickness, corresponds closely with the time at which a carpet in a service test would be discarded on account of visible wear. The deviation of the *S* index of a single test from the average is less than 10 percent in 9 trials out of 10. The nature of the wear produced by the two machines on the pile fibers was found to be similar to that produced during the service tests. The analysis of carpets do not yield sufficient data to determine the probable durability of carpets in general. The relative wear of carpets for a given use can be evaluated by means of laboratory wear tests. For general interlaboratory comparison of the relative wear resistance of carpets, the testing machines and the testing procedures must be rigidly standardized and controlled. 47 p. 20c.

RP1506. Chemically modified wools of enhanced stability. Walton B. Geiger, F. F. Kobayashi, and Milton Harris.

Recent work at this Bureau has shown that the disulfide cross-linkages of wool can be transformed to more stable *bis*-thioether linkages by a two-step process. The disulfide groups are first reduced to sulhydryl groups by means of a mercaptan, and then, by treating the wool with an aliphatic dihalide, pairs of sulfur atoms are linked together through short hydrocarbon chains. Wools modified by such a process have now been studied more extensively. It was found that they are decidedly more stable than untreated wool toward many chemical agents, including alkalies, acids, oxidizing agents, and reducing agents; are stained less easily by metals; and are attacked much less readily by certain biological agents, including moths, carpet beetles, and enzymes. 9 p. 10c.

RP1507. Measurement of densities of synthetic rubbers. Lawrence A. Wood, Norman Bekkedahl, and Frank L. Roth.

A method has been developed for preparing specimens of synthetic rubber in a form suitable for precise measurements of the density. The rubber is outgassed in a vacuum chamber, and while still under vacuum is molded into a sheet about  $\frac{1}{16}$  in. (1.6 mm) thick. Specimens weighing between 1 and 2 g each are cut from this sheet and are employed for the measurement of the density by the method of hydrostatic weighings. The values obtained with different specimens from the same sample rarely differ from each other by more than 0.05 percent. Measurements are made soon after molding because some rubbers recover, and develop roughened surfaces and vacuoles which bring about a decrease in the apparent density.

Unvulcanized Buna S, prepared in a laboratory polymerization with a minimum quantity of materials other than butadiene and styrene, was found to have a density of 25° C of 0.9291 g/cm<sup>3</sup>. Corresponding values for butadiene-styrene copolymers produced on a commercial scale are as follows: Firestone Buna S, 0.9358; U. S. Rubber Co. Buna S, 0.9369; Standard Oil Co. (N. J.) Buna S, 0.9390; Chemigum IV, 0.9391; Hycar O. S.-20, 0.9385; and Hycar O. S.-30, 0.9303 g/cm<sup>3</sup>. The densities of other common varieties of synthetic rubber were found to be as follows: Neoprene



CG, 1.2307; Neoprene E, 1.2384; Neoprene FR, 1.1406; Neoprene GN, 1.2290; Chemigum I, 1.0135; Hycar O. R., 0.9992; Perbunan, 0.9684; Thiokol RD, 1.0564; Thiokol A, 1.5983; Thiokol FA, 1.3298; and Butyl B-1.45, 0.9175 g/cm<sup>3</sup>. 6 p. 5c.

RP1508. Ten-year tests of high-early-strength cement concretes. Louis Schuman.

Data on 10-year compressive strengths of concrete cylinders made from 12 commercial high-early-strength cements are given, supplementing the results up to 1 year given in Research Paper 799. When cured in moist air, the concretes generally continued to gain strength between 1 and 10 years. For concretes stored in the air of the laboratory, the 10-year strengths are approximately equal to those at 28 days. Comparisons are given between strengths of concretes made in 1910, 1930, and 1941, showing that concretes made with some present-day cement may attain strengths in 1 month exceeding those for the older cements at 10 years. 7 p. 5c.

RP1509. Interval selector for random pulses. Francis J. Davis and Leon F. Curtiss.

An interval selector is described which has been developed to study the distribution of pulses from Geiger-Müller counters. The circuit is designed to count pulses with a separation less than  $\tau$ , where  $\tau$  may be varied between  $3 \times 10^{-5}$  sec and 0.2 sec. Tests are described which show that the circuit accomplishes these measurements with considerable precision.

Results of tests on alcohol-vapor-argon and amyl-acetate-vapor-argon-type Geiger-Müller counters are given which show that counters of this type can be prepared in a simple manner, yielding the proper random distribution of pulses even at very rapid rates of counting. Counters thus prepared have maintained their characteristics for at least 2 years. 11 p. 5c.

RP1510. Combination of wool protein with acids in mixtures, and its relation to the acid dyeing of wool. Jacinto Steinhardt, Charles H. Fugitt, and Milton Harris.

In order to extend previously reported analyses of the combination of acids with wool, measurements have been made over a wide range of concentrations, of the amounts of the anions of two acids combined by wool fibers when acids of different affinity for protein are present in different proportions or in mixtures of their acid and salt forms. It is shown that anions compete with one another for combination with the fiber, so that the amounts of each combined depend not only on the amounts initially present but also on their respective affinities for wool. The bearing of these results and their interpretation on the theory of acid dyeing is discussed, with special reference to the factors promoting the attainment of "level" or "solid" application of dye to the fibers. 8 p. 5c.

RP1511. Analysis of the selective combination of wool with acids in mixtures. Jacinto Steinhardt.

Wool immersed in mixtures of two strong acids, or of one acid and a salt of a second, combines with these acids in unequal amounts. The present paper demonstrates that the results obtained with mixtures may be predicted with fair approximation from the anion-wool dissociation constants previously assigned to each anion on the basis of titration data. Methods are described for calculating the total acid and the relative proportions of each which are bound. Conversely, it is also shown that approximate values of the dissociation constants may be calculated from the results of experiments with mixtures. 12 p. 5c.

RP1512. Further phase-equilibrium studies involving the potash compounds of portland cement. William C. Taylor.

The present research on the system  $K_2O.23CaO.12SiO_2-CaO-5CaO.3Al_2O_3$  is a part of the program designed to determine the manner in which  $K_2O$  affects the compound composition of portland cement clinker. Thermal and optical data are presented and a phase-equilibrium diagram of this system has been constructed. The only compounds that were observed in the system under equilibrium conditions are the components of the system and  $3CaO.Al_2O_3$ . The effect of  $K_2O$  on the compound composition of clinker containing  $K_2O$ ,  $CaO$ ,  $MgO$ ,  $Al_2O_3$ ,  $Fe_2O_3$ ,  $SiO_2$ , and  $SO_3$  has been studied also. The only compounds of  $K_2O$  found to be stable are  $K_2SO_4$  and  $K_2O.23CaO.12SiO_2$ , the  $K_2O$  combining preferentially with the  $SO_3$  present. 15 p. 10c.

Title page and contents for volume 29. 6 p. 5c.



RP1513. Mechanical properties of cellulose acetate as related to molecular chain length. Arnold M. Sookne and Milton Harris.

The mechanical properties of films prepared from a series of fractions of cellulose acetate, varying widely in molecular chain length ( $DP$ ), were determined. A fraction of  $DP$  30 would not form a coherent film; fractions of higher  $DP$  showed a rapid improvement of mechanical properties with increase in  $DP$ , but above 150, further improvement was slight. A close correlation was found between the results of folding endurance and ultimate elongation measurements. These properties are more sensitive than tensile strength to changes in  $DP$  and heterogeneity with respect to  $DP$ . Investigation of the properties as a function of both weight-average and number-average  $DP$  indicated that at any given weight-average  $DP$  the fractions are superior to the blends and, furthermore, those blends which contain fractions of low  $DP$  are inferior to those which do not. In contrast, at any given number-average  $DP$  within the range studied, the properties of the fractions and all of the blends are approximately equal. 14 p. 10c.

RP1514. Perforated cover plates for steel columns: Compressive properties of plates having ovaloid perforations and width-to-thickness ratio of 53. Ambrose H. Stang and Martin Greenspan.

Tests were made to determine the mechanical properties of perforated cover plates intended to be used as a substitute for lattice bars or batten plates in built-up box-type columns. Each test column was built up from one perforated plate and either two or four angles. Columns with unperforated plates were used as controls.

This paper gives the results of the tests on columns having plates of three different perforation spacings.

It was found that the perforated plates contributed to the strength, and especially to the stiffness, of the columns, and that the factor of stress concentration, due to the presence of the perforations, varied from 2 to 2.6 based on the gross area (1.7 to 2.1, based on the net area). 25 p. 10c.

RP1515. An improved electrode holder for spectrographic analysis. Bourdon F. Scribner and Charles H. Corliss.

An electrode holder has been constructed for improving the speed and ease of operations in miscellaneous spectrographic testing. Advantages afforded by the new holder include: (1) application to a variety of electrode sizes and excitation conditions, (2) positive and precise adjustment and motion of the parts, (3) water-cooling of the electrode clamps, and (4) a housing for protection against light, fumes, and electric shock. The construction of the holder and its application to excitation problems with the high-voltage spark, the a-c arc, and the d-c arc are described. 5 p. 5c.

RP1516. Nature of the reaction of wool with alkali. Louis R. Mizell and Milton Harris.

The course of the reaction of the cystine in wool with alkali has been reinvestigated. The earlier findings that one sulfur atom is split from each molecule of cystine are confirmed. Of the residual noncystine sulfur in the alkali-treated wool, more than 25 percent has been accounted for as lanthionine. No significant amounts of sulfhydryl groups are in the treated wools. The results lead to the conclusion that the alkali cleavage of the disulfide group does not consist primarily in a hydrolytic rupture between the sulfur atoms with the formation of a sulfhydryl compound and a sulfenic acid, as postulated earlier; rather, they are more consistent with a mechanism recently advanced by Nicolet and Shinn, which involves a rupture between sulfur and carbon to yield dehydroalanine and a  $-\text{CH}_2-\text{S}-\text{SH}$  residue. An atom of sulfur is then eliminated from the latter and the sulfhydryl group thus formed reacts with dehydroalanine to form lanthionine. 7 p.

RP1517. Photochemical stability of papers. Herbert F. Launer and William K. Wilson.

Papers were irradiated with a carbon arc through a filter that completely eliminated infrared, and ultraviolet shorter than approximately 330 millimicrons. Sheet temperature was kept near 30° C during irradiation, through contact with a thermostated metal backing, thereby eliminating heat effects, shown otherwise to overshadow light effects, using intense sources.

In consequence, the results differed from those of previous workers. Yellowing of papers (without lignin) commonly ascribed to light was found to result from heat or age, but not light; papers bleached when heat effects were eliminated during irradiation. Even lignified paper was bleached by light in nitrogen.

Paper scorched brown at high temperatures or yellowed at 100° C, and yellow papers 250 years old were bleached by light.

Lack of oxygen inhibits but does not altogether prevent photochemical deterioration. The role of water vapor differs fundamentally for cotton and wood-pulp paper.

Lignified paper is very unstable to light. Printers' ink extensively protects paper.

Irradiated papers are subsequently less stable in the dark than those not previously irradiated.

The order of photochemical stability of papers was as follows: new-rag, refined sulfite, old-rag, soda-sulfite, and newsprint. The light stability of new-rag papers was greatly affected by acid and rosin, whereas that of old-rag and soda-sulfite was only slightly affected, in contrast to heat stability, for which pH is important for all fibers. Newsprint, made neutral with  $\text{NaHCO}_3$ , showed a large increase in light stability. Rosin did not seriously affect the stability of any papers as long as their acidity was low. 20 p. 5c.

RP1518. Thermal expansion of some bronzes. Peter Hidnert.

The results obtained in the course of independent tests and investigations on the linear thermal expansion of four groups of bronzes designated as tin-zinc, leaded, aluminum, and silicon bronzes are given for different temperature ranges. Curves showing the typical expansion and contraction characteristics of these bronzes during heating and cooling are presented. Ternary diagrams are given to show the effect of composition on the coefficients of expansion of copper-tin-zinc and copper-tin-lead alloys. In general, the coefficients of expansion of these copper-base alloys increase as the addition of tin, zinc, or lead is increased. For the range from 20° to 100° C, the average coefficients of expansion of the various bronzes were found to be between  $16.8 \times 10^{-6}$  and  $19.0 \times 10^{-6}/^\circ\text{C}$ . 13 p. 5c.

RP1519. Analytical separations by means of controlled hydrolytic precipitation. Raleigh Gilchrist.

To ascertain the completeness of precipitation of hydroxides under conditions of controlled alkalinity in the range pH 1 to 10, experiments were made with over forty of the chemical elements.

Discussion is given of possibilities for analytical separation through controlled hydrolytic precipitation. 11 p.

RP1520. Thermal expansion of titanium. Peter Hidnert.

This paper gives data on the linear thermal expansion of titanium (97.2 percent) at various temperatures between -190° and +700° C. The coefficient of expansion of titanium increases from about  $5 \times 10^{-6}/^\circ\text{C}$  at -150° C to about  $12 \times 10^{-6}/^\circ\text{C}$  at 650° C. The data on thermal expansion do not indicate the existence of polymorphic transformations of titanium between -190° and +700° C. 5 p. 5c.

RP1521. Modification of the Carius combustion tube to minimize losses by explosion: Pressures attained on heating nitric acid to 300°C. Charles L. Gordon.

This paper describes a modified form of tube which minimizes the likelihood of loss by explosion in the Carius method of determining halogens and sulfur in organic substances. The familiar Carius tube of Pyrex glass cannot be sealed properly in the laboratory. Residual strains in the glass seals cause the tubes to burst at pressures much lower than those to be expected from the normal strength of the glass. By sealing smaller neck-tubes on the usual heavy-walled tubes, all the seals except the small final seal can be oven-annealed at the factory.

While the bursting pressure of the unmodified tubes was found to be between 1,000 and 1,400 pounds per square inch, the modified tubes burst at over 2,500 pounds per square inch. The pressures developed during a Carius determination were estimated from determinations of the pressures developed by various amounts of fuming nitric acid in a specially designed gage. Such pressures were found to be below 1,520 pounds per square inch at temperatures up to 300° C when the amount of acid was limited to that customarily used. 5 p. 5c.

RP1522. Measuring the degree of curl of paper. Frederick T. Carson and Vernon Worthington.

In a method frequently used to determine the tendency of paper to curl, a measurement is made of the amount of curl of a small piece of the paper floating on water. The measurement is customarily made in terms of an arbitrarily chosen angle. The maximum curvature, however, is a more logical measure of curliness. An effort had been made to determine the maximum curvature of freely curling paper from measurements made of the curling of paper in contact with water, and the new apparatus devised for the purpose is described. Measurements were made of the relative curliness of a



number of lithographic papers. The correlation of curl with other related properties is discussed. The results of the measurement of curl agree reasonably well with what is known about the behavior in use of the papers studied. 9 p. 5c.

RP1523. Combination of wool protein with weak acids. Jacinto Steinhardt, Charles H. Fugitt, and Milton Harris.

Previous studies of the combination of wool with strong acids have been extended to include 13 weak acids. It is shown that, unlike strong acids, these substances combine with wool in the molecular (undissociated) as well as in the ionic (dissociated) form. The amounts combined as molecules may far exceed the amounts taken up as ions.

Estimates are given of the relative tendencies of these weak acids to combine with wool. They vary over a three-hundredfold range. The negligible effect of temperature on the equilibrium between wool and one of these acids, monochloroacetic, suggests that the combination with undissociated acids is akin to a competitive solvation and involves the displacement of combined water. 6 p. 5c.

RP1524. pH values of certain phosphate-chloride mixtures, and the second dissociation constant of phosphoric acid from 0° to 60° C. Roger G. Bates and S. F. Acree.

Measurements of the electromotive forces of galvanic cells composed of hydrogen and silver-silver-chloride electrodes in aqueous chloride-phosphate solutions were made at 5-degree intervals from 0° to 60° C. The solutions were mixtures of sodium chloride, disodium hydrogen phosphate, and either sodium or potassium dihydrogen phosphate; three ratios of the molalities of the two phosphate salts were employed, and a wide range of concentrations was covered. The second dissociation constant was evaluated from the experimental data. The values of the negative logarithm of the constant at each of the 13 temperatures studied may be computed from the following equation:

$$pK_2 = 1979.5/T - 5.3541 + 0.019840T,$$

where  $T$  is in degrees Kelvin.

For each temperature, the heat and entropy of dissociation, the change of heat capacity, and the free-energy change accompanying the dissociation of 1 mole of  $H_2PO_4^-$  were computed from the variation of the second dissociation constant with temperature.

The pH value of each solution was calculated. The pH values from 0° to 60° C of mixtures of sodium (or potassium) dihydrogen phosphate, disodium hydrogen phosphate, and sodium chloride, in which  $m_{H_2PO_4} = m_{Cl}$  and the ratio of the molality of  $H_2PO_4^-$  to that of  $HPO_4^-$  lies between 0.2 and 5.0, are given by the equation

$$(pH)_i = (pK_2)_i - \log (m_{H_2PO_4}/m_{HPO_4}) - 3A\sqrt{\mu}/(1 + Ba_1\sqrt{\mu}),$$

where  $\mu$  is the ionic strength. These solutions are proposed as pH standards in the range 6.4 to 7.4. 27 p. 10c.

RP1525. Miniature Geiger-Müller counter. Leon F. Curtiss.

A miniature Geiger-Müller tube counter having a tube 0.8 mm in internal diameter is described. This "hypodermic-needle" type of counter has been found useful in locating and measuring a well-defined beam of gamma radiation. It could also be used to measure a beam of hard X-rays reflected from a crystal. Another suggested use is direct insertion into specimens, such as living biological material. 2 p. 5c.

RP1526. Occurrence of sucrose and inulin-hydrolyzing enzymes in commercial enzyme preparations. William Ward Pigman.

The relative enzyme content of enzyme preparations which hydrolyze sucrose and inulin was determined for 14 enzyme preparations representing the principal commercial types available. Those of fungal origin seem invariably to contain invertases in about 0.5 to 1.0 percent of the quantities in commercial purified yeast invertase preparations. Enzyme preparations from plant sources (wheat, almond, and malt), from animal tissues (pancreases), and from *Bacillus mesentericus* had negligible contents of invertase. Enzyme preparations from *Aspergillus niger* and yeast exhibited considerable ability to hydrolyze inulin, those from *Aspergillus oryzae* and *A. flavus* exhibited some slight activity, and preparations from other sources were essentially inactive. For several representative enzyme preparations, the rate of hydrolysis of inulin and sucrose was studied and found to approximate a first-order reaction. The activity of the inulase in several *A. niger* enzyme preparations was found to be greatest in the range pH 3 to 4. Invertase preparations from *A. niger* were most active at pH 3 to 4 and those from *A. oryzae* at pH 5.0 to 5.5.



The results are considered from the viewpoint of the Weidenhagen theory, and it is shown that the original theory is incompatible with the present results in that either the invertases and inulases are different enzymes or they represent a class of enzymes (fructofuranosidases) in which the individual members vary according to the source. Thus the ratio of invertase to inulase activity varies from about 5 for the *A. niger* preparations to more than 4,000 for the yeast preparation. Following the suggestion of Helferich, the term "emulsin" is used as a synonym for a crude mixture of enzymes.

It is shown that the *A. niger* emulsins hydrolyze juices from the jerusalem artichoke, which contain levulose polysaccharides. This reaction may be useful for the commercial production of levulose from this source, as enzymic hydrolysis has certain advantages that may offset the high cost of the enzyme preparation.

Consideration is given to the different methods available for expressing enzyme activity. It is shown, for the enzymes reported in the present paper, that the pseudo first-order reaction constant is proportional to the enzyme concentration over a fairly wide range, and that this constant may be utilized for the expression of the enzyme content of various emulsins. Since the substrate concentration must be specified, it is suggested that the concentrations proposed by Weidenhagen be generally accepted, and that his standard conditions of temperature, etc., also be adopted. 17 p. 5c.

RP1527. Perforated-cover plates for steel columns: Compressive properties of plates having circular perforations and a width-to-thickness ratio of 53. Am-brose H. Stang and Martin Greenspan.

Tests were made to determine the mechanical properties of perforated cover plates intended to be used as a substitute for lattice bars or batten plates in built-up box-type columns. Each test column was built up from one perforated plate and either two or four angles. Columns with unperforated plates were used as controls.

This paper gives the results of the tests on columns having plates of three different perforation spacings.

It was found that the perforated plates contributed to the strength and to the stiffness of the columns, and that the factor of stress concentration, due to the presence of the perforations, varied from 2.5 to 3.4 based on the gross area (2.2 to 2.8 based on the net area). 26 p. 10c.

RP1528. Part-wool blankets for use in barracks. Herbert F. Schiefer, Louis R. Mizell, and F. T. Mosedale.

The properties of 33 part-wool blankets of 8 constructions were measured, and the changes produced by 10 washings were observed. It is concluded that part-wool blankets should prove quite satisfactory for use in barracks in place of the all-wool army blanket, thereby effecting a substantial saving of wool, which might be needed for other military purposes. 6 p. 5c.

RP1529. Advantages of a blanket-and-sheet combination for outdoor use. Herbert F. Schiefer.

Blankets varying greatly in air permeability were tested alone and in combination with one and with two sheets for air permeability and thermal transmission. The air permeability of the sheets was low in comparison with that of the blankets. The results show the effect of moving air on the thermal transmission of the blankets and of the blankets between two sheets. The effect of laundering on the weight, thickness, compressibility, compressional resilience, breaking strength, air permeability, and thermal transmission of the blankets is also reported.

It is concluded that for outdoor use, where protection against the wind and rain or snow is important, as in an open lifeboat at sea, a combination of a blanket and sheet or wind-resistant cloth would afford far more protection than a blanket alone. 6 p. 5c.

RP1530. Composition and physical properties of aqueous extracts from portland cement clinker pastes containing added materials. George L. Kalousek, C. H. Jumper, and J. J. Tregoning.

Mixtures of 12 commercial portland cement clinkers and water were filtered at 7 minutes and at 2 hours after mixing, and the chemical composition, pH, conductivity, surface tension, and density of the extracts were determined. The effects on the composition and physical properties of the extracts, produced by the addition of small amounts of various materials to the pastes, were studied in parallel experiments. The added materials included gypsum, which was used in preparing the cements from the clinkers, calcium chloride, calcium acetate, fluosilicic acid, sucrose, T D A, tannic acid, and triethanolamine.

In the majority of the extracts, soda and potash were present in greater amounts

than any of the other dissolved oxides. Relatively high concentrations of sulfate occurred in the extracts of the clinkers that contained the larger amounts of potash. The lime concentration and basicity of the extracts were largely determined by the amounts of alkali oxides present. The concentration of silica corresponded approximately to the reported solubility of silica in lime solutions. Low concentrations of oxides of the  $R_2O_3$  group were found except in extracts from pastes containing the added organic materials. 41 p. 10c.

RP1531. Classification of carbohydrases. William Ward Pigman.

A system for the classification of the carbohydrases has been proposed by Weidenhagen, and, although it has considerable value, it also has a number of obvious deficiencies. It is demonstrated in the present paper that many of these difficulties may be obviated by considering the individual enzymes of Weidenhagen, e. g.,  $\alpha$ -glucosidase, as classes of enzymes of similar action but varying according to the source. The results of more recent studies of the specificity of the carbohydrases are considered, and the action of enzymes on pentoses, hexoses, and heptoses of similar ring conformations is interpreted. These results and the conception of the complex nature of Weidenhagen's individual enzymes are utilized in the establishment of a provisional system for the classification of the carbohydrases. 9 p. 5c.

RP1532. Further experimental study of beater practice in the manufacture of offset papers. Charles G. Weber, Merle B. Shaw, and Martin J. O'Leary.

Seventy-three experimental papers have been made in the Bureau's experimental paper mill in studies to determine the relationship between the mechanical beating of the fibers and the properties of offset papers made from them. A previous publication contains the data for the wood-fiber papers. The present article reports an extension of the work to include papers made of rag fibers, and mixtures of rag and wood fibers.

The rag fibers responded to beating differently in some respects than the wood fibers. Old rags withstood the prolonged beating required for the development of maximum strength and optimum formation without the adverse effects of such treatment noted in the preparation of wood fibers. All the rag-fiber papers had appreciably lower expansivity than wood-fiber papers of corresponding bond strength, and the mixture of old-rag fibers with strong sulfite, in equal proportions, produced papers with folding endurance approaching the average for the two pulps. Papers made of the sulfite pulp and wood-fiber filler pulp in like proportions have been found to have fold values little above that of the weaker pulps.

The addition of clay filler to a sulfite paper lowered the expansivity in the machine direction but did not lower it appreciably in the cross direction. 13 p. 5c.

RP1533. Effects of added materials on some properties of hydrating portland cement clinkers. Edwin S. Newman, Raymond L. Blaine, Charles H. Jumper, and George L. Kalousek.

Studies were made of the effects of added materials on the properties of a group of portland cement clinkers representing standard-portland, moderate-heat-of-hydration, high-early-strength, sulfate-resistant, and white cements. The materials used were gypsum, sugar, calcium chloride, TDA (grinding aid), tannic acid, triethanolamine, calcium acetate, and fluosilicic acid. The effects were judged by comparing the results of tests of specimens of clinker pastes containing the materials under investigation with the results of similar tests of the clinker pastes to which nothing had been added.

It was found that although some of the materials caused large changes in the behavior of the clinker pastes during their early history, these effects largely disappeared thereafter. Few of the substances had much effect on the results of tests performed at 28 days. No tests were made to evaluate the effect of the added materials after longer periods. 21 p. 10c.

RP1534. Some properties of heat-setting refractory mortars. Raymond A. Heindl and William L. Pendergast.

Twelve brands of the heat-setting type of refractory mortar were studied with respect to sieve analysis, pyrometric cone equivalent, amount of mixing water required, troweling and drying properties, and strengths after heating at various temperatures. The tendency of the mortars to shrink, crack, and adhere when exposed to high temperatures, both in fusion blocks and in units of three bricks each, was also investigated. 8 p. 5c.

RP1535. Sources of error in precise commercial refractometry. Leroy W. Tilton.

Exclusive of compensators, the mechanical requirements for accurate refractometry to a few units of the fifth decimal place in index are difficult but not impracticable.



Optical requirements are high because the symmetrical use of all apertures is, in general, not possible. If it is necessary to distinguish between index of sample referred to air at  $t$  or at  $t_0$ , this usually can be done by choice of a relative or an absolute temperature coefficient when correcting for temperature of the refractometer block. For an error of  $1 \times 10^{-5}$  in index of solids, the permissible prism of contact liquid is one-third fringe per centimeter as viewed in the exit pupil of the telescope. The requirements for minimum shielding of critically refracted rays, for absence of certain interference fringes in the field of view, and for surfacing of the illuminating prism are so related with reference to measurements on small samples of liquid that compromises are necessary in the design of precision refractometers. 18 p. 10c.

RP1536. Nature of the prismatic dark interstitial material in portland cement clinker. William C. Taylor.

As a result of a series of previous investigations by the phase equilibrium method, it has been concluded that  $K_2SO_4$  and  $K_2O.23CaO.12SiO_2$  are the only compounds containing  $K_2O$  that may exist when a mixture of  $K_2O$ ,  $CaO$ ,  $MgO$ ,  $Al_2O_3$ ,  $Fe_2O_3$ ,  $SiO_2$ , and  $SO_3$ , in the proportions occurring in portland cement clinker, is heated and cooled under equilibrium conditions. Frequent observations of a prismatic dark interstitial phase in etched, polished sections of commercial clinker and in rapidly cooled laboratory clinkers led to the present study of the relation of this phase to the system  $K_2O.23CaO.12SiO_2-CaO-5CaO.3Al_2O_3$  and to other systems involving  $K_2O$ . The prismatic phase has not been found to exist under equilibrium conditions, but has been produced only under conditions of rapid cooling. Both thermal and compositional conditions that have been found to be required for its formation suggest that it may be a metastable form of  $3CaO.Al_2O_3$  and monotropic with respect to the stable, isotropic, rectangular  $3CaO.Al_2O_3$ . That portion of  $K_2O$  combined as  $K_2SO_4$  has been found to have no effect in inducing the formation of the prismatic phase. The conditions necessary for the formation of this phase have been outlined. Although the exact composition has not been established definitely, because of the experimental difficulties that have been outlined, the close relationship between the prismatic phase and  $3CaO.Al_2O_3$  leads to the recommendation that this phase be referred to as "prismatic  $3CaO.Al_2O_3$ " instead of the term "prismatic dark interstitial material." 18 p. 15c.

RP1537. Dissociation constants and pH-titration curves at constant ionic strength from electrometric titrations in cells without liquid junction: Titrations of formic acid and acetic acid. Roger G. Bates, Gerda L. Siegel, and S. F. Acree.

An improved method for obtaining the titration curves of monobasic acids is outlined. The sample, 0.005 mole of the sodium salt of the weak acid, is dissolved in 100 ml of a 0.05- $m$  solution of sodium chloride and titrated electrometrically with an acid-salt mixture in a hydrogen-silver-chloride cell without liquid junction. The acid-salt mixture has the composition: nitric acid, 0.1  $m$ ; potassium nitrate, 0.05  $m$ ; sodium chloride, 0.05  $m$ . The titration therefore is performed in a medium of constant chloride concentration and of practically unchanging ionic strength ( $\mu = 0.1$ ). The calculations of pH values and of dissociation constants from the emf values are outlined. The titration curves and dissociation constants of formic acid and of acetic acid at 25° C were obtained by this method. The pK values (negative logarithms of the dissociation constants) were found to be 3.742 and 4.754, respectively. 13 p. 5c.

RP1538. Function of carbon dioxide in producing efflorescence on plaster and cement products. Dana L. Bishop.

Hydrated magnesium sulfate was identified as the principal compound in efflorescence on white-coat plaster finish. This salt is not a constituent of the white-coat backing but is formed by reactions involving gypsum and magnesia in the plaster, carbon dioxide from the air, and water. The reaction to form magnesium sulfate cannot take place until after the  $Ca(OH)_2$  has been changed to  $CaCO_3$ . Magnesium sulfate efflorescence may also be formed on cement products by the same reactions. 6 p. 5c.

RP1539. Study of the system  $CaO-Al_2O_3-H_2O$  at temperatures of 21° and 90°C. Lansing S. Wells, W. F. Clarke, and H. F. McMurdie.

A study has been made of the system  $CaO-Al_2O_3-H_2O$  at temperatures of 21° and 90° C. Diagrams have been constructed showing the solubility relations of the various phases at these temperatures. The solid phases were investigated by petrographical and X-ray diffraction methods. By means of X-ray diffraction patterns, it was found that the so-called hexagonal tricalcium aluminate hydrate is in reality a mixture of hexagonal  $2CaO.Al_2O_3.8H_2O$  and hexagonal  $4CaO.Al_2O_3.13H_2O$  intercrystallized in equimolecular proportions. On standing at room temperature, dry dicalcium aluminate



hydrate is slowly converted into the tetracalcium aluminate hydrate and hydrated alumina. Loss of water of hydration in the tetracalcium aluminate hydrate results in a decrease in the unit cell along the *c* axis. Although the hexagonal di- and tetracalcium aluminate hydrates exist only as metastable phases in the system between 21° and 90° C, their approximate solubility relationships were ascertained at 21° C. As the temperature increases, the hexagonal aluminates become less stable. The only stable phases that occur in the system  $\text{CaO-Al}_2\text{O}_3\text{-H}_2\text{O}$  at atmospheric pressure over the temperature range of 21° to 90° C are gibbsite ( $\text{Al}_2\text{O}_3\cdot 3\text{H}_2\text{O}$ ), the isometric tricalcium aluminate hexahydrate ( $3\text{CaO}\cdot\text{Al}_2\text{O}_3\cdot 6\text{H}_2\text{O}$ ), and  $\text{Ca}(\text{OH})_2$ . The solubility curves of these three stable phases in the system  $\text{CaO-Al}_2\text{O}_3\text{-H}_2\text{O}$  were determined at 21° and 90° C. Over this temperature range, gibbsite is the stable phase up to a concentration of 0.33 g of CaO per liter; at concentrations greater than this,  $3\text{CaO}\cdot\text{Al}_2\text{O}_3\cdot 6\text{H}_2\text{O}$  is the stable phase until those points are reached at which  $\text{Ca}(\text{OH})_2$  also appears as a solid phase. The series of invariant points for gibbsite and the isometric phase occur at a concentration of 0.33 g of CaO per liter, but with the concentration of  $\text{Al}_2\text{O}_3$  increasing from 0.02 g of  $\text{Al}_2\text{O}_3$  per liter at 21° C to 0.11 g of  $\text{Al}_2\text{O}_3$  per liter at 90° C. 43 p. 10c.

RP1540. Perforated cover plates for steel columns: Compressive properties of plates having a net-to-gross cross-sectional-area ratio of 0.33. Ambrose H. Stang and Martin Greenspan.

Tests were made to determine the mechanical properties of perforated cover plates intended to be used as a substitute for lattice bars or batten plates in built-up box-type columns; Each test column was built up from one perforated plate and four angles. Two columns had circular and two ovaloid perforations. For each column the ratio of net-to-gross cross-sectional area in the plate was 0.33.

In this paper the methods of test are described, and the results of the tests of the four columns are given. 16 p. 10c.

RP1541. Thermal expansivity and density of indium. Peter Hidnert and Mary Grace Blair.

The linear thermal expansion of cast indium of high purity was investigated between -190° and +100° C and the cubical thermal expansion between 0° and 50° C. The following equation was derived for the linear expansion of indium:

$$L_t = L_0[1 + (28.9t + 0.0134t^2) 10^{-6}],$$

where  $L_0$  represents the length of the metal at 0° C, and  $L_t$  the length at any temperature,  $t$ , within the range of the observations. The average coefficients of cubical expansion of indium were found to be  $77 \times 10^{-6}$  and  $101 \times 10^{-6}$  per degree centigrade for the ranges 0° to 25° C and 25° to 50° C, respectively. These coefficients of cubical expansions are not equal to three times the coefficients of linear expansion for the corresponding temperature ranges on account of the anisotropy of indium.

The density of cast indium was found to be 7.281 g/cm<sup>3</sup> at 22.6° C. The density of indium calculated from the best available data on atomic weights and lattice constants is 7.40 g/cm<sup>3</sup>. Observed densities at 0°, 25°, and 50° C are also given in this paper. 7 p. 5c.

RP1542. Measurements of ultraviolet solar radiation in Washington, 1936 to 1942. W. W. Coblentz and R. Stair.

Continuing earlier measurements of ultraviolet solar radiation (RP877), a summary is given of similar measurements made during the years 1936 to 1942, in Washington, D. C. Marked variations in the spectral quality and total intensity of ultraviolet solar radiation, attributable to variations in atmospheric turbidity, and, to a less extent, to well-known cyclonic and seasonal changes in ozone concentrations in the stratosphere, are recorded. On the clearest days the biologically effective ultraviolet of wavelengths shorter than 3132 Å, incident directly from the sun and the surrounding sky at midday, ranges from about 75 microwatts per square centimeter ( $\mu\text{w}/\text{cm}^2$ ) in midsummer to about 12  $\mu\text{w}/\text{cm}^2$  in midwinter. 13 p. 5c.

RP1543. A tungsten-in-quartz lamp and its applications in photoelectric radiometry. R. Stair and W. O. Smith.

This paper gives constructional data relating to a tungsten-filament-in-quartz lamp and a discussion of its applications to precision filter radiometry. This lamp is adapted for use in the calibration of the spectral and total radiation sensitivity of phototubes. In its applications, it supplements the spectroradiometer for calibrating phototubes while employing the tubes with the associated filters used in measuring the radiation under the investigation.

The spectral radiation output from such a lamp depends upon the temperature

of the filament, the emissivity of tungsten, and the transmission of the fused-quartz envelope. A table of relative blackbody radiation intensities has been calculated for the temperature range 2,500° to 2,900° K in the wavelength interval 2300 to 3500 angstroms. 11 p. 10c.

RP1544. Effect of turbulence and channel slope on translation waves. Garbis H. Keulegan and George W. Patterson.

This paper is the second of a series dealing with the motion of flood waves and other waves of translation in open channels. The first paper considered waves controlled solely by inertia forces; the present one is an analysis of the combined effects of turbulent friction and inertia. The basic equation of motion for gradually varied unsteady flow in prismatic channels is derived from fundamental principles. The effect of the velocity distribution in the original undisturbed current on the motion of short waves is investigated, and the effects of wave height, curvature of profile, and fluid friction on the celerity of a wave-volume element is analyzed in detail. The deformation of a straight sloping front and the change of height of an abrupt wave front is treated. Special emphasis is laid on disturbances of negligible curvature and practical methods of handling engineering problems arising in connection with the operation of locks or hydroelectric canals are given. 52 p. 10c.

Title page and contents for volume 30. 6 p. 5c.

RESEARCH PAPERS FROM NATIONAL BUREAU OF STANDARDS JOURNAL OF RESEARCH  
VOLUME 31, JULY—DECEMBER 1943

RP1545. Width and spacing of tensile cracks in axially reinforced concrete cylinders. David Watstein and Douglas E. Parsons.

In a study of the spacing and width of tensile cracks, axially reinforced cylinders were tested by applying tensile forces to the reinforcement and observing the deformations of the concrete and the spacing and the width of cracks. The test data and theoretical equations were in good agreement with respect to the effects of the principal factors controlling the spacing and the width of cracks. The spacing and the width of cracks were found to depend chiefly on the ratio of the diameter to the percentage of reinforcement and the nature of the deformations on the bars. It is concluded that the use of a type of reinforcement bar that will afford more reliable anchorage would result in better control of cracking of reinforced concrete and economy in the use of reinforcement steel. 24 p. 10c.

RP1546. Autographic load-elongation apparatus for fibers. Arnold M. Sookne and Henry A. Rutherford.

An autographic load-elongation apparatus for testing single fibers is described. The apparatus is adapted to making a continuous load-elongation record at constant rate of elongation and to making a point by point record at constant rate of loading. It is also useful for obtaining relaxation curves for single fibers. It combines the principles of a hand-operated machine developed in this laboratory and an automatic electronic balance developed by Muller and Garman [5].<sup>2</sup> Sensitive automatic operation is attained by means of photoelectric controls, and autographic recording in rectangular coordinates is provided. Examples are given of the performance of the apparatus. 7 p. 10c.

RP1547. Ring structures and mutarotations of the modifications of *d*-galacturonic acid. Horace S. Isbell and Harriet L. Frush.

A study of the two crystalline modifications of galacturonic acid has been made with the object of determining their ring structure. The results show that they are a pair of alpha-beta pyranoses analogous to the alpha and beta galactopyranoses. On oxidation with bromine water, the two modifications yield optically active lactones of mucic acid. 12 p. 5c.

RP1548. Ten-year tests on commercial masonry cements. R. L. Blaine.

In an investigation of the properties of 41 commercial masonry cements reported in 1934, additional specimens were made for test at a later age. Two-inch mortar cubes made of these cements were tested in compression after both water and air storage for 10 years. Mortar bar specimens were measured for linear change after storage in water for 10 years.

The compressive strengths of the 1:3 (cement to standard sand) mortar cubes varied from 200 to 6,000 lb/in.<sup>2</sup> at 10 years. Variables such as type of cement, amount of mixing water, ratio of cement to sand, gradation of sand, as well as storage conditions are shown to affect not only the strength at 10 years but also the gain in strength between 28 days and 10 years.

The length measurements indicate a trend of greater expansion with greater magnesia content of the cement. 9 p. 5c.



RP1549. Tristimulus specification of the Munsell book of color from spectrophotometric measurements. Kenneth L. Kelly, Kasson S. Gibson, and Dorothy Nickerson.

The development of the Inter-Society Color Council-National Bureau of Standards (ISCC-NBS) system of color names, based on the standards in the Munsell Book of Color, made it necessary to specify the master standards of this book in fundamental terms. Accordingly, spectral reflection curves were run for each of the 421 master standards on the General Electric recording spectrophotometer at the National Bureau of Standards, using slit widths of approximately 4 millimicrons. Various corrections were applied to these spectrophotometric data in accordance with methods regularly used for such work at the Bureau. Colorimetric computations were then made with these data, resulting in tristimulus specifications according to the 1931 ICI standard observer and coordinate system. Four illuminants were used: ICI illuminants A and C, representative of incandescent-lamp light and average daylight, respectively, illuminant "D" (lightly overcast north sky), and illuminant "S" (extremely blue sky). The colorimetric specifications of the Munsell standards for all four illuminants are thus given.

The trilinear coordinates for the Munsell standards calculated for ICI illuminant C have been plotted on large chromaticity ( $x, y$ ) diagrams and constant Munsell chroma lines drawn in. (Similar values obtained by Glenn and Killian at the Massachusetts Institute of Technology in 1935 for Munsell color standards bearing the same hue-value-chroma designations have also been plotted on the diagrams and differences between the two sets of data are discussed.) These diagrams serve as means for determining the Munsell notation and thereby the ISCC-NBS color name for any color whose trilinear coordinates and apparent reflectance are given. 22 p. 25c.

RP1550. Thermal expansion of some industrial copper alloys. Peter Hidnert and George Dickson.

This paper gives data on the linear thermal expansion of some industrial copper-nickel, copper-nickel-aluminum, copper-nickel-tin, and miscellaneous copper alloys (copper-tin, copper-lead-antimony, copper-manganese-aluminum, copper-nickel-iron, copper-nickel-zinc, copper-nickel-tin-lead, copper-nickel-zinc-iron, copper-tin-zinc-lead, copper-zinc-aluminum-iron-manganese) for various temperature ranges between 20° and 900° C. The addition of 3 percent of nickel or the combined addition of 4.5 percent of nickel and 5 percent of aluminum to copper was found to have little effect on the linear thermal expansion. The effect of various treatments on these copper-nickel and copper nickel-aluminum alloys was also small. The coefficients of expansion of two copper-nickel-tin alloys containing 20 and 29 percent of nickel were appreciably less than the coefficients of expansion of copper for temperature ranges between 20° and 600° C. Three copper alloys containing more than 28 percent of nickel showed the smallest coefficients of expansion of the miscellaneous alloys. The coefficients of expansion of the copper alloys reported in this paper were found to be between  $14.9 \times 10^{-6}$  and  $20.4 \times 10^{-6}$  per degree centigrade for the range from 20° to 100° C. 6 p. 5c.

RP1551. Optical rotation and atomic dimension: The four optically active 2-halogenopentanes. Dirk H. Brauns.

In previous articles by the author it is suggested that certain optically active halogen derivatives may be divided into two classes. The first class has the halogen directly attached to an asymmetric carbon atom. For these substances the writer has formulated the rule that the differences of their specific rotations, (Cl-F), (Br-Cl), and (I-Br) have the same numerical relation as the respective differences of the radii of the covalent-bonded atoms (41:17:21). The second class of optically active halogen derivatives has the halogen attached indirectly (by a chain of atoms) to an asymmetric carbon atom. For these latter substances the rule was formulated that the differences of their molecular rotations have a numerical relation, which likewise agrees with that for the respective differences of the radii of the neutral halogen atoms.

As these rules were established for halogen derivatives of carbohydrates, which contain several asymmetric carbon atoms, it was found desirable to investigate halogen derivatives, which contain only one asymmetric carbon. The results of the last investigation (see footnote 1) showed that the derivatives of the amyl alcohol, 2-methylbutanol-1, checked the above rule for the second class very well. The present communication reports the results obtained in checking the above rule for the first class with the halogen derivatives of the other active amyl alcohol, pentanol-2. Pure optically active *D*- and *L*-pentanol-2 were prepared and halogenated by different methods in order to obtain the 2-fluoro-, 2-chloro-, 2-bromo-, and 2-iodopentanes of highest rotation.

In spite of the difficulty that a partial inversion takes place in the halogenation,



resulting in a mixture of *D* and *L* halogen derivative, the conclusion can be drawn that rule I is not contradicted by the values found, since the deviations can be plausibly explained by the incompleteness of the Walden inversion. Rule II should not be applicable to this type of compound, and the results confirm this.

It is further shown that all halogen derivatives of pentanol-2 of like configuration have the same sign of optical rotation. The specific gravity, refractive index, and boiling points at various pressures were also determined. 24 p. 10c.

RP1552. Tensile and other properties of concretes made with various types of cements. Louis Schuman and John Tucker, Jr.

An improved tensile-test method for concrete has been developed. Cylindrical specimens, 4 by 16 inches, are used, and loads are applied at both ends through threaded rods embedded in a rich mortar. Compressive- and tensile-strength and stress-strain determinations have been made for concretes made with various types of cements, including cements with aerating agents, and with various aggregates. At early ages, strengths for moderate-heat cements were but slightly lower than for normal cements, whereas those for high-early-strength cements were considerably higher. Tensile strengths usually attained maximum values between 7 days and 3 months. Tensile strengths depended on compressive strengths, type of cement, type of aggregate, and on sand-gravel ratios. 18 p.

RP1553. Properties of cast red brass as affected by the ambient atmosphere during melting. Harold B. Gardner, Alexander I. Krynetsky, and Charles M. Saeger, Jr.

A study was made of the physical properties of red brass (Cu, 85; Sn, 5; Pb, 5; Zn, 5), melts of which had been made and poured in an atmosphere of hydrogen, nitrogen, methane, carbon dioxide, carbon monoxide, and air. The tensile properties, hardness, density, and electrical resistivity of the sand-cast bars, in general were inferior to those of the chill-cast metal. For both the sand-cast and chill-cast bars, hydrogen and methane had deleterious effects. The effect of hydrogen was most pronounced and detrimental. The unsoundness of the hydrogen-treated metal, as shown by microstructural study and by density surveys, is the most important factor responsible for the inferior properties of the metal treated in this way. 16 p. 10c.

RP1554. Electrical and mechanical properties of the system Buna S-gilsonite. Alan H. Selker, Arnold H. Scott, and Archibald T. McPherson.

Buna S compounds containing gilsonite have properties that render them suitable for the insulation of communication cables. The principal limitation of these compounds as produced at the time of this investigation was that Buna S contained constituents which caused relatively high water absorption. Electrical measurements were made of gilsonite and of compounds of Buna S containing from 0 to 56 percent of gilsonite by volume, i. e., from 0 to 150 parts by weight per 100 parts of Buna S and 12 parts of other ingredients. The base compound contained, in parts by weight: Buna S, 100; stearic acid, 2; zinc oxide, 5; accelerator, 2; and sulfur, 3. The dielectric constant of this base compound at 1,000 cycles per second was 2.85, and the power factor  $30 \times 10^{-4}$ ; the d-c conductivity was  $11 \times 10^{-16}$  mho/cm 1 minute after application of potential. Under the same conditions the dielectric constant of the gilsonite alone was 2.60, the power factor  $15 \times 10^{-4}$ , and the conductivity less than  $2 \times 10^{-16}$  mho/cm. Most of the requirements of the United States Coast Guard specifications for the insulation of submarine cable were met by a compound containing 25.6 percent of gilsonite by volume, or 40 parts of gilsonite by weights per 100 parts of Buna S and 12 parts of other ingredients. This compound had the following properties: dielectric constant at 1,000 cycles per second, 2.78, and power factor,  $65 \times 10^{-4}$ ; d-c conductivity,  $4 \times 10^{-16}$  mho/cm; tensile strength, 1,200 lb/in<sup>2</sup>; ultimate elongation, 470 percent; tensile stress at an elongation of 200 percent, 560 lb/in<sup>2</sup>. At the frequencies at which the measurements were made, namely 100, 1,000, 7,500, and 100,000 cycles per second, the dielectric constant of the base compound decreased from 2.88 to 2.78, and the power factor increased from  $15 \times 10^{-4}$  to  $145 \times 10^{-4}$ . The change with frequency became smaller with additions of gilsonite. Extraction of the Buna S with water before compounding removed about 0.8 percent of water-soluble materials and reduced the absorption of water to about one-third of the value for the commercial material. The change of dielectric constant on immersion in water was reduced by prolonged washing of the Buna S, but the power factor was little affected. 21 p. 10c.

RP1555. Calcium chloride compounds of *D*- $\alpha$ -glucoheptose (*D*-glycero-*D*-gulo-aldo-heptose). Horace S. Isbell and Harriet L. Frush.

In support of the concept that sugars having like configurations for the atoms comprising the pyranose ring have like properties, it has been found that *D*-glycero-

*D-gulo*-aldoheptose (formerly *D-α*-glucoheptose) resembles *D-gulose* in that it forms crystalline compounds with calcium chloride, and in that the equilibrium which exists in aqueous solutions is shifted in marked degree by changes in the concentration of calcium chloride. It was shown that the addition of calcium chloride shifts the equilibrium toward the unknown alpha-pyranose modification. The equilibrium optical rotation of *D-glycero-D-gulo*-aldoheptose in a 4-percent aqueous solution in the presence of calcium chloride varies according to the relationship

$$[\alpha]_D^{20} = -20.2 + 3.54m - 0.067m^2,$$

in which *m* is the grams of calcium chloride per 100 ml of solution. A crystalline compound, *β-D-glycero-D-gulo*-aldoheptose.  $\text{CaCl}_2 \cdot 2\text{H}_2\text{O}$ , was prepared and its mutarotation was measured. In 4-percent aqueous solution,

$$[\alpha]_D^{20} = -6.5 \times 10 - .0072t - 9.3$$

6 p. 5c.

RP1556. Density of leather and its significance. Joseph R. Kanagy and Everett L. Wallace.

The real density of leather calculated from the weight of a measured volume, allowing for voids, and the apparent density of leather calculated from the weight of a measured volume, not allowing for voids, were studied. The real-density values of different samples of leather and a sample of raw hide were determined by a method in which Boyle's law is applied. The apparent density of some of these samples, obtained by direct dimensional measurement and by displacement of mercury, is compared with the real density. The real densities of most of the samples vary within a narrow range (1.387 to 1.516), whereas the apparent densities vary over a greater range, depending upon the treatment. For this reason the apparent density is believed to be a more valuable factor for most practical considerations. The influence of location of the specimen on the hide on real density is considered, and results that show the effect of compression on both densities are given. Moisture content is shown to have considerable influence on the real density. For leathers that do not have abnormally high grease contents, the permeabilities to air and water vapor appear to show some correlation to the percentage of voids, which is calculated from the ratio of the apparent to the real density. 11 p. 5c.

RP1557. A counting method for the determination of small amounts of radium and of radon. Leon F. Curtiss and Francis J. Davis.

A method for determining small quantities of radon is described, in which the alpha particles from the radon and RaA and RaC are counted in an ion-counting chamber. Details of an arrangement for automatically making a printed record of the hourly totaled count are given. Advantages of this method over that using an ionization chamber with electrometer are discussed. 15 p.

RP1558. The assay of potassium *p*-phenolsulfonate, its pH range, and its ultraviolet absorption spectrum. Elizabeth E. Sager, Marjorie R. Schooley, and S. F. Acree.

Potassium *p*-phenolsulfonate is a good buffer for the pH range of 8.4 to 9.2 and for spectrophotometric studies of metacresolsulfonphthalein and thymolsulfonphthalein. Its useful pH range lies between those for borates and secondary phosphates and therefore fills an important gap. The purified product is not commercially available, and quantitative tests for indicating its purity have not been reported. It was found that a pure product may be obtained after only three recrystallizations. A quantitative method of analysis by bromometric titration was developed. Two molecules of bromine react quantitatively with 1 molecule of *p*-phenolsulfonate in molar hydrochloric acid at 0° C within 5 minutes.

Ultraviolet absorption spectra were obtained and showed differences between the primary and the secondary salt. The spectrophotometric data indicate that the sulfonate group is almost completely ionized in dilute solutions. 8 p. 5c.

RP1559. The second dissociation constant of *p*-phenolsulfonic acid and pH values of phenolsulfonate-chloride buffers from 0° to 60° C. Roger G. Bates, Gerda L. Siegel, and S. F. Acree.

The thermodynamic dissociation constant of the phenol group of *p*-phenolsulfonic acid was calculated from electromotive-force measurements of hydrogen-silver-chloride cells without liquid junction. Thirty-nine buffer mixtures of potassium *p*-



phenolsulfonate, sodium hydroxide, and sodium chloride were studied in five series of experiments from 0° to 60° C at intervals of 5 degrees. In three series, the molal ratio of phenolsulfonate ion to phenolate-sulfonate ion was unity, and in two series the buffer ratio was 2:3. For two series of experiments, one at each buffer ratio, the molality of sodium chloride was maintained constant near 0.05 for all dilutions of the buffer. In the other experiments, the molality of each component of the solution varied between 0.0037 and 0.1.

The values of  $pK_2$ , the negative of the common logarithm of the second dissociation constant, between 0° and 60° C are given by the equation

$$pK_2 = 1961.2/T - 1.1436 + 0.012139T,$$

where  $T$  is in degrees Kelvin.

Equations were formulated to give the changes of free energy, heat content, entropy, and heat capacity that accompany the dissociation at infinite dilution of a mole of phenolsulfonate ion at any temperature between 0° and 60° C. For the dissociation of the phenol group at 25° C,  $\Delta F^\circ$  is 12,351 cal,  $\Delta H^\circ$  is 4,036 cal,  $\Delta S^\circ$  is  $-27.9$  cal deg $^{-1}$ , and  $\Delta C^\circ p$  is  $-33$  cal deg $^{-1}$ .

The pH value of each buffer-chloride mixture was calculated from the experimental data and the activity coefficients that were found to characterize each series of solutions. The pH values of other phenolsulfonate buffers which have molal ratios,  $m_1/m_2$ , of phenolsulfonate ion to bivalent phenolate-sulfonate ion between 2/3 and 1 can be computed for temperatures between 0° and 60° C with an accuracy of  $\pm 0.002$  unit from their compositions and from the dissociation constants and ionic parameters given in this paper. The equation used is

$$pH = pK_2 - \log(m_1/m_2) - 3A\sqrt{\mu}(1 + 8B\sqrt{\mu}),$$

where  $\mu$  is the ionic strength. Buffer solutions of this type are suitable pH standards in the range 8.6 to 9.0. 19 p. 10c.

RP1560. X-ray patterns of hydrated calcium silicates. Howard F. McMurdie and Einar P. Flint.

X-ray powder diffraction data of 15 hydrated calcium silicates are reported as a supplement to a previously published report on the formation of these compounds. These data may be useful to workers on portland cement hydration, boiler scale, etc., for the identification of phases. 4 p. 5c.

RP1561. Structure of the wool fiber as revealed by the electron microscope. Charles W. Hock and Howard F. McMurdie.

An investigation of the wool fiber with the electron microscope was undertaken in order to get more data on the structure of the fiber and its constituent cells, and to correlate this information with results previously obtained by other methods. Specimens were prepared for examination by various physical and chemical procedures.

Over a wide range of magnifications the cortical cells always showed a distinctly fibrous structure, whereas with the optical microscope only fibrils were observed within the cortical cells, the higher resolving power of the electron microscope made possible the resolution of still finer microfibrils. The scale cells, on the other hand, showed little internal organizations. This difference in structure between the fibrous cortex and the nonfibrous or amorphous cuticle is believed to be of fundamental importance in interpreting many of the properties of the fibers. 8 p. 10c.

RP1562. A friction meter for determining the coefficient of kinetic friction of fabrics. Edwin C. Dreby.

A friction meter is described, and its application to the evaluation of the smoothness of a wide variety of fabrics is discussed. The ruggedness, sensitivity, and ease of operation of the instrument make it suitable for the routine testing of fabrics, the evaluation of finishing agents, and the control of finishing processes. 10 p. 5c.

RP1563. Abrasion and solution of teeth. Wilmer Souder and Irl C. Schoonover.

Minute changes in the surfaces of teeth are detected by observing the injury to calibrated indentation marks made in these surfaces by a diamond hardness indenter.

Abrasive and chemical injuries are disclosed by observing or photographing a series of these marks, so placed that each small area is definitely identifiable.

Objectionable abrasives in dentifrices are readily detected by brushing a tooth surface on which indentations have been placed.

The indentations also give an indication of the hardness of the tooth and enable the investigator to select areas of known hardness for experimental tests.



Some data are presented to show the initial effects of chemical solutions and bacterial actions, which may play important roles in the development of dental caries. Eleven figures and two tables correlate the experimental work. 7 p. 10c.

RP1564. Report on the systems lead oxide-alumina and lead oxide-alumina-silica. R. F. Geller and E. N. Bunting.

Phase relations were studied for those portions of the binary and the ternary systems containing over 50 percent of PbO. It is reasonably certain that the binary system contains the compound  $\text{PbO} \cdot \text{Al}_2\text{O}_3$ . In the ternary system 3 compounds ( $8\text{PbO} \cdot \text{Al}_2\text{O}_3 \cdot 4\text{SiO}_2$ ,  $4\text{PbO} \cdot \text{Al}_2\text{O}_3 \cdot 2\text{SiO}_2$ , and  $6\text{PbO} \cdot \text{Al}_2\text{O}_3 \cdot 6\text{SiO}_2$ ) were identified, 4 others were indicated by optical and X-ray properties, and 10 quintuple points, which include 6 eutectics, were established. Also,  $\text{Al}_2\text{O}_3$  (99.9 plus purity) was observed to melt at  $2,035^\circ \text{C}$ . 16 p. 10c.

RP1565. Color designations for lights. Kenneth L. Kelly.

An extension of the ISCC-NBS (Inter-Society Color Council-National Bureau of Standards) system of color names for the description of the colors of drugs and medicines, has been made for describing the colors of lights. The color names consist of hue names, such as red, pink, yellowish green, or purple, without further modifiers, since they are intended to differentiate lights chiefly according to hue. The hue names are among those used in the ISCC-NBS system and carry the same meaning. The chromaticity ranges identified by each of these hue names are defined by areas on the ICI chromaticity diagram. Comparisons are made between the centers of the proposed hue-name ranges and similar values by other authorities, and with the standard colors recognized in various specifications for marine, railway, aviation, and traffic signal colors. 8 p. 5c.

RP1566. Iron as a tanning agent. Joseph R. Kanagy and Ruth A. Kronstadt.

Lactic, citric, hydroxyacetic, and gluconic acids were found satisfactory for stabilizing iron solutions to be used for tanning leather. The influence of pH and concentration on the combination of iron ( $\text{Fe}_2\text{O}_3$ ) with standard hide powder was investigated. The maximum fixation of 23 to 25 percent of ferric oxide occurs in the pH range 3.5 to 4.0. Practical tanning experiments were made with goat- and calf-skins. The shrinkage temperatures of the iron-tanned leathers are lower than those of well-tanned chrome leathers. The results of accelerated aging tests indicate that all of the iron-tanned leathers tested had at least fair aging qualities except where gluconic acid was used. The use of iron salts for replacing those of chromium in the tanning of leather shows most promise where citric acid is used for stabilizing the solutions. 11 p. 5c.

RP1567. pH values of acid-salt mixtures of some aromatic sulfonic acids at various temperatures and a criterion of completeness of dissociation. Walter J. Hamer, Gladys D. Pinching, and S. F. Acree.

A method is described to differentiate between completely and incompletely dissociated acids by means of measurements of the emf of galvanic cells without liquid junctions. Hydrogen and silver-silver-chloride electrodes and solutions of the acid, its sodium or potassium salt, and sodium or potassium chloride are used. The activity coefficients of hydrochloric acid in such mixtures are calculated by the equation relating the emf to the activity of hydrochloric acid in known concentrations of the acid and salts. If the mean values of the activity coefficient of hydrochloric acid in the mixtures are higher than those predicted by the limiting law of Debye and Hückel, the acid is then considered to be completely dissociated. If they are lower, the acid is incompletely dissociated. By this method it was found that the sulfonic acid group in *p*-phenolsulfonic and 4-chlorophenol-2-sulfonic acids may be regarded as completely dissociated into sulfonate and hydrogen ions at temperatures of  $10^\circ$ ,  $25^\circ$ ,  $40^\circ$ , and  $60^\circ \text{C}$ .

Solutions containing *p*-phenolsulfonic acid, its sodium or potassium salt, and sodium or potassium chloride and solutions containing 4-chlorophenol-2-sulfonic acid, its sodium salt, and sodium chloride are suitable for use as pH standards. Their pH values range from 1.2 to 2.5 and vary only slightly with temperature changes. Directions for their preparation are given.

The significance of the complete dissociation of the sulfonic acid group in the calculation of the ionization constants and pH values of sulfonate buffers and indicators is discussed in terms of the tautomeric relations and the theory of color changes of indicators. 14 p. 5c.

RP1568. Axial rigidity of perforated structural members. Martin Greenspan.

Formulas are derived for computing the over-all lengthening (or shortening) of a tension (or compression) member having a uniform gross cross section and a series

of similar perforations of circular, elliptical, or "ovaloid" shape uniformly distributed along the length.

Tests made on strips having circular perforations show that the applicable formula gives good results over the practical range of the variables. 18 p. 10c.

RP1569. Basic ionization constant of metacresolsulfonphthalein; pH values and salt effects. Elizabeth E. Sager, Harry J. Keegan, and S. F. Acree.

Spectral transmittancy values at room temperatures approximating 25° C were obtained for  $1.25 \times 10^{-5}$  M metacresolsulfonphthalein in water and in 0.001- to 8-M hydrochloric acid. In water the indicator exists in the yellow form (Y), and hydrogen ions (H) from acids convert it into the red form (R). The molar concentrations of each form of the indicator in various concentrations of hydrochloric acid were computed from the spectrophotometric data. The dissociation constant ( $K_b$ ) for the reaction of the indicator with hydrochloric acid is given by the equation

$$K_b = M_{HfH}M_{YfY}/M_{RfR},$$

in which  $M$  and  $f$ , with appropriate subscripts, represent the molarities and activity coefficients, respectively. The value of  $K_b$  is  $1.98 \times 10^{-2}$  and that of  $-\log K_b$  or  $pK_b$  is 1.703  $\pm$  0.005. The indicator is useful over the pH range 0 to 3. 21 p. 10c. Title page and contents for volume 31. 6 p. 5c.

RESEARCH PAPERS FROM JOURNAL OF RESEARCH OF THE NATIONAL BUREAU OF STANDARDS, VOLUME 32, JANUARY—JUNE 1944

RP1570. Dicalcium silicate solid solutions. Kenneth T. Greene.

Studies on the manner of combination of  $\text{Na}_2\text{O}$  in portland cement clinker have revealed crystalline phases of chemical composition near that of  $2\text{CaO} \cdot \text{SiO}_2$ , but possessing properties quite different from those heretofore reported for the  $\beta$  form of this compound. These phases result when certain compositions in the quaternary systems  $\text{Na}_2\text{O}-\text{CaO}-\text{Al}_2\text{O}_3-\text{SiO}_2$  and  $\text{Na}_2\text{O}-\text{CaO}-\text{Fe}_2\text{O}_3-\text{SiO}_2$  are quenched from high temperatures. Optical, thermal, and X-ray diffraction data have been obtained which indicate that they are solid solutions of  $\text{Na}_2\text{O}$  and  $\text{Al}_2\text{O}_3$  and of  $\text{Na}_2\text{O}$  and  $\text{Fe}_2\text{O}_3$ , in a high-temperature form of  $2\text{CaO} \cdot \text{SiO}_2$  having a hexagonal structure. There is also evidence that this hexagonal lattice is the fundamental structure of the  $\alpha$  form of  $2\text{CaO} \cdot \text{SiO}_2$ .

In the pure compound the  $\alpha$ - $\beta$  inversion temperature has been reported to be  $1,420^\circ \pm 2^\circ \text{C}$ , whereas in the phases described in this paper the transformation temperature may be lowered by as much as  $245^\circ \text{C}$ , e. g., to  $1,175^\circ \pm 10^\circ \text{C}$ . The inversion from  $\alpha$  to  $\beta$  is accompanied by considerable ex-solution of dissolved material, showing that the extent of solid solution of these oxides in  $\beta$ - $2\text{CaO} \cdot \text{SiO}_2$  is much less than in the  $\alpha$  form. As a result of this precipitation the grains of  $\beta$   $2\text{CaO} \cdot \text{SiO}_2$  are more or less densely clouded, closely resembling the grains of  $2\text{CaO} \cdot \text{SiO}_2$  in some commercial clinkers. The data also indicate that the complex twinning structure often observed in  $2\text{CaO} \cdot \text{SiO}_2$  in portland cement clinker and in experimental preparations is the result of inversion from the  $\alpha$  to the  $\beta$  phase, and is not typical of the  $\alpha$  modification, as some investigators have believed. 10 p. 10c.

RP1571. Hydrocarbons in the gasoline fraction of seven representative crudes, including all the distillate to  $102^\circ \text{C}$  and the aromatic to  $160^\circ \text{C}$ . Alphonse F. Forziati, Charles B. Willingham, Beveridge J. Mair, and Frederick D. Rossini.

This paper is the second report of an investigation on the analysis of the gasoline fraction of representative crude petroleum by the API Research Project 6 at the National Bureau of Standards. The samples for analysis were selected so as to cover the largest possible range in composition; included one high in aromatics, one high in isoparaffins, one high in normal paraffins, and one high in naphthenes (cycloparaffins); and came from the following fields: Ponca, Okla.; East Texas; Bradford, Pa.; Greendale-Kawkawlin, Mich.; Winkler, Tex.; Midway, Calif.; Conroe, Tex. The fractionating processes of adsorption and distillation were used in the analysis.

Data are given on the amounts of the individual hydrocarbons (paraffins and naphthenes,  $40^\circ$  to  $102^\circ \text{C}$ , and aromatics to  $160^\circ \text{C}$ ) in the gasoline fraction of the seven naphthas. A number of conclusions have been drawn from the data. 27 p. 10c.

RP1572. Measurement of the refractive index and dispersion of optical glass for control of product. Helen L. Gurewitz and Leroy W. Tilton.

Commercial critical-angle refractometers are inadequate for acceptance tests on optical glass for precision uses. To facilitate spectrometer determinations, coefficients have been devised which, together with a table of natural sines and slide-



rule operations, permit the computation of refractive indices of glass with an accuracy of  $\pm 3 \times 10^{-6}$  from minimum-deviation data taken on prisms having angles of  $60^\circ \pm 30'$ . 6 p. 5c.

RP1573. Interpretation of some reactions in the carbohydrate field in terms of consecutive electron displacement. Horace S. Isbell.

An attempt has been made to show how the concept of consecutive electron displacement that has been developed in recent years may be used for the interpretation of certain reactions in the carbohydrate field. The viewpoint in general is that the peculiar properties of systems involving double bonds may be explained by the migration of electron pairs in the molecule from points of high electron density to points of lower electron density, with the addition and elimination of ions. A number of apparently unrelated complex reactions of the carbohydrates are considered and it is shown that the formation of the products may be explained by a few simple reactions involving shifts of electron pairs; these include enolization, de-enolization and double decomposition. Mechanisms are presented for the formation of the four classes of saccharinic acids from the 1,2- the 2,3-, and the 3,4-enediols, for the formation of diacetylkojic acid from acetylglucosone, for the formation of unsaturated lactones from hydroxy acids, for the conversion of triacetylglucal to diacetylpsudoglucal, for the conversion of tetramethyl-1, 2-glucoseen to  $\omega$ -methoxymethylfurfural, and for the formation of furfural and levulinic acid. 15 p. 5c.

RP1574. Measuring the rate of wear of tire treads. Frank L. Roth and William L. Holt.

The rates of wear of different tread materials were determined by weighing tires after running them prescribed distances on the roads. The method proved feasible for passenger car tires, involved a minimum amount of work, and yielded data in a few miles of driving which could be used to predict the life of the tread. This paper presents typical results obtained on five different tread materials, including prewar natural rubber treads. The rate of wear of the least resistant tread material was eight times that of the most resistant material. 5 p. 5c.

RP1575. A precision apparatus for the rapid determination of indices of refraction and dispersion by immersion. Conrad A. Faick and Bernard Fonoroff.

A new immersion method for determining indices of refraction and  $\nu$  values, employing the double-diaphragm method for securing oblique illumination, is described. The average error in the determination of indices of refraction based upon 144 measurements is  $2 \times 10^{-5}$ ; the maximum error is  $5 \times 10^{-5}$ . Complete measurements of the indices of refraction for the sodium *D* line and the hydrogen *F* and *C* lines may be made in approximately  $1\frac{1}{2}$  hours, and from these measurements the  $\nu$  values may be calculated with an average error of 0.1 and a maximum error of 0.8. 9 p. 10c.

RP1576. Salts of galacturonic acid and their application to the preparation of galacturonic acid from pectic substances. Horace S. Isbell and Harriet L. Frush.

Twelve new salts of galacturonic acid have been prepared and their properties investigated. Crystalline sodium, potassium, ammonium, cadmium, and silver galacturonates have been found to contain the beta pyranose modification, and crystalline calcium and strontium galacturonates, the alpha modification. A unique type of double salt containing a monovalent and a divalent metal in combination with the alpha pyranose modification of galacturonic acid has been obtained, and the following members of this class have been crystallized and studied: Sodium calcium, sodium strontium, sodium barium, sodium cadmium, sodium lead, and potassium calcium galacturonates. Mutarotation studies have been conducted in order to determine the structure of the galacturonate component in the salts. The crystallizing properties of the normal calcium and strontium galacturonates, and especially of the sodium calcium and sodium strontium galacturonates, makes these salts particularly suitable for the separation of galacturonic acid from the hydrolytic liquors of plant materials. 18 p. 10c.

RP1577. Note on the macroanalysis of carbon and hydrogen by combustion. Donald D. Wagman and Frederick D. Rossini.

This note describes the present state of the development of an analytical combustion apparatus for the accurate determination, on a macro scale, of carbon and hydrogen in hydrocarbons or in compounds containing carbon, hydrogen, and oxygen. The precision and accuracy attainable are indicated by a report of the results of a series of five experiments performed on highly purified benzoic acid. 6 p.



RP1578. Thermal expansion of concrete aggregate materials. Walter H. Johnson and Willard H. Parsons.

As a part of a study of the properties of concrete aggregates, thermal-expansion determinations were made on 123 specimens of aggregate materials by the optical interferometer method over the temperature range  $-20^{\circ}$  to  $+60^{\circ}$  C. Additional measurements were made on crystals of calcite, quartz, and feldspar. The thermal expansivities of most aggregate materials are close to or within the range of expansivities of hardened portland cements. Certain exceptions are pointed out. Crystal orientation, rock texture, and composition are discussed with regard to their effects on the relation of the thermal expansion of aggregates to the durability of concrete. 26 p. 10c.

RP1579. Scale substance of wool. Walter B. Geiger.

Earlier work at this Bureau has shown that wool that has been reduced with thioglycolic acid and then alkylated with ethyl bromide is attacked by pepsin in such a way that the scale material remains intact, whereas the interior of the fiber is completely dissolved. The composition of the scale material so obtained has now been studied. It has been found that it is essentially protein in chemical nature and, although it contains the same amino acids as the whole wool, the proportions of these in the two materials differ; thus, the whole wool used in this work contained 12.2 percent of cystine, 8.6 of arginine, 6.1 of tyrosine, and 9.5 of serine, whereas the scale material contained 20.3, 4.8, 3.3, and 11.2 percent, respectively. 4 p. 5c.

RP1580. Effect of sodium chloride on the pH of *p*-phenolsulfonate buffers from  $0^{\circ}$  to  $60^{\circ}$  C. Roger G. Bates and S. F. Acree.

The electromotive forces developed between the hydrogen and silver chloride electrodes of galvanic cells which contained 12 mixtures of potassium *p*-phenolsulfonate, sodium hydroxide, and sodium chloride were measured from  $0^{\circ}$  to  $60^{\circ}$  C at intervals of 5 degrees. Sufficient alkali was used to neutralize half of the phenolsulfonate in each solution. The molal ratios of sodium hydroxide to sodium chloride were 10, 4, 2, and 1. The pH of each solution, and of six phenolsulfonate buffers without sodium chloride, was determined. Equations are given to represent the change of pH at each of the 13 temperatures with molality of sodium chloride. It is shown that the ionic strength and pH of unknowns may be obtained approximately, and the usual salt errors largely eliminated, from emf measurements on two portions of the unknown solution to which different amounts of sodium chloride have been added. 13 p. 10c.

RP1581. Thermal expansion of high-silicon cast iron. Peter Hidnert and George Dickson.

This paper gives data on the linear thermal expansion of high-silicon cast iron containing approximately 14 percent of silicon, with 3 percent of molybdenum and without appreciable molybdenum, at various temperatures between  $20^{\circ}$  and  $700^{\circ}$  C. Differences between the coefficients of expansion of these high-silicon cast irons were found to be slight. Both high-silicon irons were found to have slightly higher coefficients of expansion than electrolytic iron for temperature ranges between  $20^{\circ}$  and  $300^{\circ}$  C, and appreciably higher coefficients for higher temperature ranges. No indication of growth similar to that of ordinary cast iron was observed on heating the high-silicon cast iron to  $700^{\circ}$  C. 5 p. 5c.

RP1582. Analytical determination of aromatic hydrocarbons by adsorption. Beveridge J. Mair and Alphonse F. Forziati.

A simple method is described for determining the amount of aromatic hydrocarbons in a mixture of hydrocarbons, as in the gasoline fraction of petroleum. The mixture to be analyzed is filtered through a column of solid adsorbent. An aromatic-free filtrate is obtained which contains the paraffin, naphthene, or olefin hydrocarbon which was associated in the original solution with the quantity of aromatic hydrocarbon which has been adsorbed. The concentration of an aromatic hydrocarbon in an unknown solution is determined by means of a calibration curve, established from experiments on known solutions which show the amount of aromatic-free filtrate produced by the standard adsorbent from solutions of various concentrations of the aromatic hydrocarbon. Results of experiments are given for several concentrations of eight binary solutions of an aromatic hydrocarbon with a paraffin or naphthene hydrocarbon and for three concentrations of a solution consisting of an aromatic hydrocarbon with a paraffin and an olefin. These experiments show that, if the temperature is controlled to within  $1^{\circ}$  C, the amount of aromatic hydrocarbon can be determined with an accuracy corresponding to 0.10 or less in the percentage by volume. A general procedure is given for determining the aromatic hydrocarbons in a "straight-run" gasoline and in a gasoline containing olefins. 14 p.

RP1583. Separation and recovery of aromatic hydrocarbons from paraffins and naphthenes by adsorption. Beveridge J. Mair and Alphonse F. Forziati.

A method is described for separating, by the process of adsorption, the aromatic hydrocarbons from their mixture with paraffin and naphthene (cycloparaffin) hydrocarbons, as in the gasoline or kerosine fractions of petroleum. The mixture is introduced into the top of a column containing an appropriate excess of solid adsorbent. A low-boiling paraffin hydrocarbon, such as pentane, butane, or propane, is then added in sufficient quantity to remove from the column the paraffin and naphthene hydrocarbons but not the aromatic hydrocarbons. The latter are then removed by adding an appropriate desorbing liquid, such as methanol. The paraffins, naphthenes, and pentane are thus obtained as a mixture from which the pentane is easily removed by distillation. The aromatic hydrocarbons are obtained as a mixture with pentane and methanol. The methanol is easily removed by extraction with water and the pentane by distillation.

This method of separation was tested on a known mixture of 17 pure hydrocarbons, the normal boiling points of which covered a range from 60° to 174° C and included all of the 5 normal paraffins from *n*-hexane through *n*-decane, the isoparaffin 2-methylpentane, the 4 normal alkyl cyclohexanes from cyclohexane through *n*-propylcyclohexane, and all of the 7 possible aromatic hydrocarbons and benzene through isopropylbenzene. The separation of the aromatic hydrocarbons from the paraffins and naphthenes was quantitative within the limits of measurement, and their recovery was complete within the normal operating loss of material in processing.

Experimental determinations were made of the quantity of aromatic hydrocarbon adsorbed per unit quantity of adsorbent, for a number of different binary solutions or aromatic hydrocarbons with paraffins or naphthenes, at several concentrations of the aromatic hydrocarbon, and with silica gel, carbon, magnesia, alumina, Filtrol, and Florisil as adsorbents. The results are displayed in the form of adsorption isotherms. 19 p.

RP1584. Method for determining individual hydrocarbons in mixtures of hydrocarbons by measurement of freezing points. Anton J. Streiff and Frederick D. Rossini.

A method is described for determining individual hydrocarbons in mixtures of hydrocarbons by the measurement of freezing points. Experimental data are given for the determination of the four C<sub>8</sub> aromatic hydrocarbons. The uncertainty of the determination of each hydrocarbon is near  $\pm 1$  percent of the total sample. 11 p.

RP1585. Theoretical analysis of certain time-temperature freezing and melting curves as applied to hydrocarbons. William J. Taylor and Frederick D. Rossini.

A method is described for determining analytically or graphically, from appropriate time-temperature freezing and melting curves obtained on hydrocarbons, the freezing point of a given substance, and within certain wide limits, the freezing point of that substance for zero impurity (liquid-soluble, solid-insoluble). 17 p.

RP1586. A method for the determination of the pH of 0.05-molal solutions of acid potassium phthalate with or without potassium chloride. Walter J. Hamer and S. F. Acree.

The pH values of a 0.05-*m* solution of acid potassium phthalate containing various amounts of potassium chloride were determined at 5-degree intervals from 0° to 60° C, inclusive, from the measurements of the electromotive force of galvanic cells without liquid junction using hydrogen and silver-silver-chloride electrodes. A method is described for the determination of the pH directly from the emf by means of the equation

$$\text{pH} = [(E - E^\circ)/(RT/F) + \log m_{\text{Cl}} - P]/Q,$$

where *P* and *Q* are constants whose numerical values depend on the ionic strength of the solution and the nature of the cation and *E*<sup>°</sup>, *R*, *T*, and *F* have their usual significance. By this method a 0.05-*m* solution of acid potassium phthalate, National Bureau of Standards Standard Sample 84a, is found to have a pH of 4.008 at 25° C, and this value does not vary much with the temperature. A description is also given of the application of the method to the determination of the pH and the ionic strength of unknown solutions of low salt content.

Equations were formulated to express the variation of the pH of a 0.05-*m* solution of acid potassium phthalate with temperature and with the concentration of potassium chloride. The pH values may be computed for temperatures from 0° to 60° C, inclusive, by the equation.

$$\text{pH} = 5.13 \log T + 1519.62/T + 0.01092 T - 17.039,$$



where  $T = t^{\circ}\text{C} + 273.16$ . The pH values for concentrations of potassium chloride from 0 to 0.05  $m$  may be computed by the equation.

$$\text{pH}_{\text{with salt}} = \text{pH}_{\text{without salt}} - 0.993m_{\text{KCl}} + 2.124m_{\text{KCl}}^2.$$

The solutions may be readily prepared from known weights of acid potassium phthalate, potassium chloride, and distilled water and are well suited for use as pH standards, in that their pH values do not change much with temperature or dilution. 13 p. 5c.

RP1587. Thermal properties of moist fabrics. Charles W. Hock, Arnold M. Sookne, and Milton Harris.

The "chilling effect", or "clamminess", that moist fabrics produce when in contact with the body was evaluated by subjective tests, by measurement of the drop in temperature that ensued when the moist fabrics were placed on an artificial "skin" surface, and by tests with a moisture-sensitive paper designed to measure the extent of contact which the fabrics made with a surface. Using fabrics of various fiber compositions and constructions, a good qualitative relation was found in these tests. Fabrics which produced considerable chilling in subjective tests were found to make good contact and to cause a substantial drop in skin temperature. Conversely, fabrics which caused little or no clamminess made poor contact and the accompanying drop in temperature was relatively small. The results of these experiments show clearly the progressive improvement of the fabrics with respect to chilling, as their wool content is increased, and also the superiority of certain types of construction that minimize the extent of contact of the fabrics with the skin. 24 p.

RP1588. Purification of substances by slow fractional freezing. Frank W. Schwab and Edward Wichers.

This paper describes two technics for purifying substances by slow fractional freezing.

The first involves the slow lowering of a cylindrical cell, filled with the fused substance, through a heating coil in such a way that freezing begins at the bottom and progresses upward, as the cell emerges from the coil, until the whole mass has solidified. The solidified column, tube and all, is cut into the desired fractions.

The second technic, which is suitable for larger quantities, affords better control of the rate of freezing and provides a larger solid-liquid surface for a given quantity of material. A spherical flask filled with the liquid is cooled at a controlled rate in such a way that freezing begins at the wall of the flask and proceeds inward at a regulated slow rate until the desired fraction has solidified, after which the remaining liquid is siphoned out of the flask.

The purification of benzoic acid was much more rapid by this method than in earlier trials by crystallization from solvents. Acetanilide was also effectively purified. Observations incidental to the work show that the freezing point of pure acetanilide is  $114.29 \pm 0.01^{\circ}\text{C}$ . 7 p. 5c.

RP1589. A study of the properties of household blankets. Herbert F. Schiefer, Hazel Tharp Stevens, Pauline Beery Mack, and Paul M. Boyland.

The fiber composition, weight, thickness, compressibility, compressional resilience, thermal transmission, air permeability, breaking strength, and shrinkage of 156 different blankets are recorded. The effects of laundering; of laundering and renapping; of laundering, renapping, and abrasion; of dry cleaning and renapping; and of dry cleaning, renapping, and abrasion on these properties of a large number of blankets are shown. A linear relationship was found between the compressional resilience and the wool content of cotton-wool blankets. The thermal transmission of the blankets was found to be independent of the kind of fiber. The reciprocal of thermal transmission was found to be related linearly to the thickness. The thermal transmission computed by means of the equation  $1/T = 3.0 t_{0.1} + 0.63$ , where  $T$  is the thermal transmission in  $\text{Btu}/(^{\circ}\text{F hr 1 ft}^2)$ , and  $t_{0.1}$  is the thickness in inches at a pressure of  $0.10 \text{ lb/in.}^2$ , was found to agree with the measured values within  $\pm 10$  percent, 95 times out of 100. Empirical relationships were also found among thermal transmission, thickness at  $1.0 \text{ lb/in.}^2$ , and compressibility; and among thickness at  $0.10 \text{ lb/in.}^2$ , compressibility, and weight. The relation between breaking strength and weight, and that between breaking strength and compressibility, are discussed. Minimum requirements are suggested for the properties of blankets for use in a performance specification. 24 p. 15c.



RP1590. Studies of portions of the quaternary system soda-lime-silica-water at 25° C.  
George L. Kalousek.

A study has been made of portions of the system soda-lime-silica-water at 25° C. The only solid phases found were  $\text{Ca}(\text{OH})_2$  and a four-component gel of variable composition. The boundary,  $\text{Ca}(\text{OH})_2$  — soda-lime-silicate gels, was determined and the compositions of the gels along this boundary shown to vary from 0.003- $\text{Na}_2\text{O} : 2.0\text{CaO} : 1.0\text{SiO}_2 : x\text{H}_2\text{O}$  (at 0.2 g of  $\text{Na}_2\text{O}$  per liter) to about 0.25  $\text{Na}_2\text{O} : 1.0\text{CaO} : 1.0\text{SiO}_2 : x\text{H}_2\text{O}$  (at 20 g per liter and extending to 101 g per liter of  $\text{Na}_2\text{O}$ ). In regions off the boundary, at selected constant concentrations of  $\text{Na}_2\text{O}$  but with increasing concentrations of  $\text{SiO}_2$  in solution, the  $\text{Na}_2\text{O} : \text{SiO}_2$  molar ratio of the gels varied only slightly from 0.2 in most cases; the  $\text{CaO} : \text{SiO}_2$  molar ratio, however, decreased to values approaching 0.1 at the maximum concentrations of  $\text{SiO}_2$  used. Interpretations pertaining to relations between the composition of the gels and solutions are given. 18 p. 10c.

RP1591. Laminar flow at the interface of two liquids. Garbis H. Keulegan.

The velocity distribution in the laminar boundary layers at the interface of two liquids in relative rectilinear motion, the thickness of the layers, and the stress at the interface are determined. Numerical results are given for nine cases of liquids in contact, including identical liquids and liquids with varying degrees of dissimilarity in characteristics. The evaluation of the desired quantities is based on Prandtl's boundary-layer theory, and is carried out by a method of successive approximations. The numerical results are those given by the second approximation. 25 p. 10c.

Title page and contents for volume 32. 6 p. 5c.

RESEARCH PAPERS FROM JOURNAL OF RESEARCH OF THE NATIONAL BUREAU OF  
STANDARDS, VOLUME 33, JULY—DECEMBER 1944

RP1592. Thermodynamic properties of *cis*-2-butene from 15° to 1,500°K.

Russell B. Scott, W. Julian Ferguson, and Ferdinand G. Brickwedde

The following properties of a sample of *cis*-2-butene, 99.94 percent pure, were measured: (1) the specific heat of solid and of liquid from 15° to 300°K, (2) heat of fusion at the triple point (130.25 int. joule  $\text{g}^{-1}$ ), (3) triple-point temperature ( $-138.900 \pm 0.008^\circ\text{C}$ ), (4) heats of vaporization at several temperatures between 246° and 293°K, and (5) vapor pressure from 200° to 296°K. With these experimental data, calculations were made of (1) the normal boiling temperature (3.718°C), (2) volume of the saturated vapor, (3) enthalpy and entropy of the solid and the liquid from 0° to 300°K, and (4) entropy, enthalpy, and specific heat of the vapor in the ideal gas state from 245° to 300°K. Thermodynamic functions for *cis*-2-butene in the ideal gas state from 300° to 1,500°K were calculated from spectroscopic data. Thermodynamic data for the *cis-trans* isomerization of 2-butene are included. 20 p. 10c.

RP1593. A daily record of ultraviolet solar and sky radiation in Washington, 1941 to 1943. .... W. W. Coblentz and R. Stair

A description is given of a photoelectric ultraviolet-intensity meter and automatic integrating and recording apparatus for measuring the biologically effective component of ultraviolet radiation, of wavelengths 3132 Å and shorter, from the sun and the entire sky, incident on a horizontal plane, under various meteorological conditions. Methods of standardization, in absolute value, are described (see RP1542 for supplementary data). A continuous graphical record of the integrated daily total amount of biologically effective ultraviolet solar and sky radiation observed during a period of 3 years (1941 to 1943) in Washington, D. C. is given. The monthly totals of biologically effective ultraviolet, in absolute value (milliwatt minutes per square centimeter)  $\text{mw min/cm}^2$  are also given graphically. On the clearest days the biologically effective component of ultraviolet radiation of wavelengths 3132 Å and shorter, incident from the sun and the whole sky at midday, ranges from about 180 microwatts per square centimeter, ( $\mu\text{w/cm}^2$ ) in midsummer to about 30  $\mu\text{w/cm}^2$  in midwinter. A series of erythema tests is given, correlating the physical (radiometric) measurements with the physiological reaction of the untanned skin, which information is of interest in heliotherapy and bioclimatology. 24 p. 10c.

RP1594. Synthesis of vitamin C from pectic substances. .... Horace S. Isbell

A new process for the preparation of vitamin C from beet pulp and other pectic substances has been developed. The pectic substance is treated with a pectinase, the resulting galacturonic acid is separated in the form of a difficultly soluble salt which is reduced with hydrogen to a salt of L-galactonic acid. The salt is converted to L-galactono-lactone and oxidized to 2-keto-L-galactonic acid, which is lactonized and enolized to yield ascorbic acid (vitamin C). Electronic interpretations are pre-

sented for the conversion of methyl 2-keto-L-galactonate to ascorbic acid by basic catalysts, for the lactonization and enolization of 2-keto-hexonic acids by acid catalysts, and for the formation of furfural and reductic acid from pentoses, galacturonic acid, and ascorbic acid. 17 p. 10c.

RP1595. Specific heat and increases of entropy and enthalpy of the synthetic rubber GR-S from 0° to 330° K.

Robert D. Rands, Jr., W. Julian Ferguson, and John L. Prather

Specific heat measurements were made over the range 12° to 330° K on a sample of synthetic rubber GR-S (Buna S) by means of an adiabatic vacuum-type calorimeter. A Debye specific heat function was used to calculate values below 15° K. At about -61°C the material undergoes a transition of the second order, the specific heat increasing rapidly by about 40 percent. From -50° to +60°C, the specific heat values can be calculated to within 0.1 percent by the equation  $C_p = 0.4346 + 7.029 \times 10^{-4} t + 1.156 \times 10^{-6} t^2$  in calories gram<sup>-1</sup> degree Kelvin<sup>-1</sup>. At 25°C the specific heat is 1.894 international joules gram<sup>-1</sup> degree Kelvin<sup>-1</sup> (0.4528 calorie gram<sup>-1</sup> degree Kelvin<sup>-1</sup>). The increase in entropy from 0° to 298.16° K is calculated to be 1.824 international joules gram<sup>-1</sup> degree Kelvin<sup>-1</sup> (0.4359 calorie gram<sup>-1</sup> degree Kelvin<sup>-1</sup>). Values of specific heat, and increases of entropy, enthalpy, and free energy are tabulated at 5-degree intervals. The experimental data indicate that values below the transition are dependent upon the thermal history of the sample. This phenomenon, as well as the temperature drifts observed, can be explained on the theory that the transition results from an increasingly slow approach to the equilibrium state at temperatures in the transition region and below. 8 p.

RP1596. Dipole moment and structure of trioxane. Arthur A. Maryott and S. F. Acree

Trioxane is a solid polymer of formaldehyde resembling the well-known solvent dioxane in its chemical properties. The molecule can possibly exist in two spatially different forms resembling a chair and a cradle, for which the theoretical dipole moments are 2.3 and  $0.6 \times 10^{-18}$  electrostatic unit (esu), respectively. The experimental value in benzene was found to be  $2.18 \times 10^{-18}$  esu. Hence it is concluded that ordinary trioxane is largely in the chair form, possibly in equilibrium with a small amount of the cradle form. This cyclic ether would therefore be suitable for mixing with nonpolar solvents to study the effect of increased polarity on the activities and absorption spectra of indicators. 4 p. 5c.

RP1597. Interferometer measurements on the expansion of iron. James B. Saunders

The interferometer has been applied by many investigators to the measurement of thermal expansion but has failed to yield the precision that they apparently expected and sometimes have claimed. In their explanation of the resultant discrepancies, most observers have attributed them to actual differences in the physical properties of the sample; however, some have admitted failure to find a satisfactory explanation.

Several sets of data, taken on relatively pure iron by different observers and different procedures, are compared. The results show good agreement between data taken with those interferometer methods that are free from tilting of spacers and air-film errors, whereas the failure to eliminate these two errors produces data that cannot be duplicated except by chance. The interferometer data that are free from these errors also agree satisfactorily with data that have been obtained by other precision methods.

Some investigators claim to have found indications of a characteristic temperature effect in the expansivity curve of iron in the temperature range from 0° to 250°C. It is shown that when the expansion data are freed from errors of tilting and changes in air films, the indications of such effects do not appear. 9 p. 10c.

RP1598. A comparison of platinum and palladium hydrogen-electrodes in aqueous solutions of acid potassium phthalate. Walter J. Hamer and S. F. Acree

A study was made of the reproducibility of hydrogen electrodes of various types and of silver-silver-chloride electrodes of the thermal-electrolytic type in aqueous solutions of phthalates, in order to learn whether phthalates are reduced to hexahydrophthalic acid and the electromotive force thereby changed. If so, glass electrodes would have to be used to determine the pH values of solutions of phthalates. This type of study is necessary for all reducible materials. Electromotive-force measurements of the electrode combinations were made for various periods of time. The potentials of hydrogen electrodes prepared with platinum sponge under a variety of conditions constantly increased with time and frequently were erratic, whereas those made with palladium sponge under different conditions remained remarkably constant for periods of 35 hours. Even after 75 hours, the potentials increased only 0.3



mv—which corresponds to an increase of only 0.005 in pH. Palladium or platinum electrodes having the same type of coating but of different ages agreed in potential after 2 hours in phthalate solutions. The rate and the magnitude of the increase in potential for the platinum electrodes after approximately 2 hours depend mainly upon the thickness of the metallic sponge. The characteristics of the palladium electrodes were practically independent of the thickness of the metallic sponge; of the current density used in the electrolysis; of the concentration, composition, acidity, and conductance of the plating solution; and of the concentration, composition, pH, and buffer capacity of the phthalate solutions in which the electrodes were used. The difference in the behavior of platinum and palladium hydrogen-electrodes may be caused by their different catalytic activity. 17 p. 10c.

RP1599. Extent of hydrolysis of starches by amylases in the presence and absence of yeasts ..... William Ward Pigman

The extent of enzymic conversion of corn starch, waxy maize starch, and potato amylose into materials fermentable by yeasts was studied for a number of different types of amylases. When the amylases are allowed to act on the starch substances, complete conversion to fermentable material may take place when the yeasts are allowed to act in the presence of the enzymes but not when the amylases and yeast act separately. The amylases that are capable of bringing about complete conversion are the cereal  $\alpha$ -amylases and the fungal amylases. Certain bacterial amylases, pancreatic amylases, and the cereal  $\beta$ -amylases convert starch only partially to fermentable substances in the presence of yeasts. The experiments described in the present paper were carried out at starch concentrations comparable to those employed in industrial grain-alcohol processes.

With the notable exception of the malt amylases and the  $\beta$ -amylases, all of the enzyme preparations studied are capable of synthesizing unfermentable substances from maltose and presumably from starch hydrolysis products. For certain of the enzyme preparations, this synthesizing action provides an explanation for the lack of complete conversion of the starches to fermentable materials. For other enzymes, however, other explanations are more probable. The nature of the actions of the amylases are considered in relation to the structures of the starch substances.

Improved procedures are given for the preparation of soybean  $\beta$ -amylase and of potato amylose. Methods are described for bringing starches into solution without preliminary gel formation. 12 p. 5c.

RP1600. A physical method for determining residual water and other volatile materials in pure substances. .... Frank W. Schwab and Edward Wichers

A method is described for determining small amounts of water and other volatile substances present as impurities in various organic and inorganic compounds. The impurity is separated by fusing the substance in a cell attached to a collecting system and allowing it to freeze slowly while the vapors are collected by pumping them into a trap of known volume, cooled by liquid air. When the trap is warmed to room temperature, the pressure of the vapor within it, if below saturation, together with the temperature and volume, determine the quantity of impurity in terms of moles and if its identity is known, in terms of weight. An auxiliary procedure permits the impurity to be isolated as a liquid, in a capillary container, and thus to be identified.

It was found that the current Standard Samples of benzoic acid (39f and 140) contains less than 0.002 percent of water and do not adsorb water on exposure to an atmosphere of high humidity. The method is further illustrated by the determination of residual solvents in acetanilide crystallized from benzene and from a mixture of alcohol and water, and of water present in potassium dichromate as entrapped mother liquor. 8 p. 5c.

RP1601. Optical rotation as an indication of aromatic substituent influences and intramolecular interaction. .... William Ward Pigman

As a result of a comparison of the rotations of certain aromatic  $\beta$ -glucosides and their tetraacetates, it is shown to be probable that the rotations of the acetylated glucosides are influenced by steric interactions between the aglycon group and the sugar portion of the molecule. This behavior is in contrast to the influences predominating in the case of the unacetylated compounds which, as shown in previous work, probably operate on the resonance of the aglycon aromatic ring or in an inductive fashion.

As a test for the explanation of the anomalous positive rotations of certain of the acetylated  $\beta$ -glucosides, the rotation of several of these substances in nitrobenzene solution was measured over the temperature interval 20° to 150°C. Over this temperature range, several of the glucosides, and in particular those which



show anomalous positive rotations at room temperature, exhibit a change in sign of rotation from positive to negative.

The preparation and properties of the following new compounds are described: The *m*-nitrophenyl  $\alpha$ -D-glucoside and its tetraacetate, the *o*,*p*- and *o*,*o'*-dinitrophenyl  $\beta$ -glucoside tetraacetates, and the *m*-nitrobenzyl  $\beta$ -glucoside tetraacetate. The rotatory dispersion of these and other glucosides is reported for five wavelengths over the visible spectrum. 16 p. 5c.

RP1602. Soil-corrosion studies, 1941: Ferrous and non-ferrous corrosion-resistant materials and nonbituminous coatings.

Kirk H. Logan and Melvin Romanoff

The soil-corrosion investigation started in 1922 was intended to yield information on the corrosiveness of typical soils throughout the United States. The investigation of special materials and coatings begun 10 years later was intended primarily to assist manufacturers in the development of materials suitable for use in corrosive soils.

No attempt to secure specimens such that systematic data on the effect of individual alloying elements could be obtained was made but, manufacturers were invited to submit materials on which they desired information. Furthermore, the specimens were buried under simulated practical conditions, so that accurate technical control was not feasible. Also, since very few specimens of each type were included, dispersion of the data resulting from the general conditions of the tests makes it impossible to draw very definite conclusions with regard to the comparative merits of the several materials investigated. Nevertheless, the data give a general indication of what may be expected of a considerable variety of alloys when exposed to severe soil conditions. The addition of very small percentages of alloying elements does not have a marked effect on the rate of corrosion, but rather large percentages are apt to bring about a considerable improvement in corrosion resistance.

Steels high in nickel and chromium, and copper alloys high in copper are very resistant to nearly all soil conditions. Lead corrodes only slightly when a coating of an insoluble lead salt is deposited on the lead.

Bursting and crushing tests indicate that asbestos-cement pipe gained somewhat in strength from exposure to the soil for 4 years.

A 3-ounce coating of zinc adds about 3 years to the life of steel exposed to some of the most corrosive soils in the test sites. Lead coatings appear to be inadequate for severe soil conditions.

Several thick experimental coatings prevented practically all corrosion at most of the test sites for 9 years. Air-dried Bakelite coatings blistered within 4 years, but a baked-on Bakelite coating showed no change in appearance after 4 years except for a few blisters. Pitting occurred under some of these blisters. Most thin coatings blistered, became brittle, and within 4 years permitted rusting and pitting of the metal to which they were applied. 52 p.

RP1603. Revised results obtained with certain dehydrating agents used for drying gases.....John H. Bower

This paper is a revision of a former paper, and as a result of further study it includes two revised values. New samples of anhydrous magnesium perchlorate, or Amhydron, silica gel, and alumina were obtained and tested for dehydrating efficiency. The method used was similar to that described in the earlier paper, except that a drying tower replaced the U-tube and each desiccant was tested separately. No change of efficiency value was obtained with anhydrous magnesium perchlorate, but new values for silica gel and alumina were found and replace the values originally given. 2 p.

RP1604. Stress-corrosion tests of bridge-cable wire.....Rolla E. Pollard

Stress-corrosion cracks were produced in several statically stressed specimens of cold-drawn wire from the Portsmouth Bridge and in one specimen of heat-treated wire from the Mt. Hope Bridge by immersion in dilute nitrate solutions. No cracks were produced in the cold-drawn Mt. Hope replacement wire after long exposure. No cracks were produced by immersing similar specimens in more corrosive media such as distilled water or dilute ammonium sulfate or in inhibitive solutions such as dilute ammonium nitrate or dilute sodium hydroxide. The results conform, in this respect, to the selective corrosion theory of intercrystalline attack. However, due to the limited amount of materials and their incompletely known history, the effect of such factors as composition, fabrication and heat treatment of the steel could not be determined. 11 p. 10c.

RP1605. Transformations of the fundamental equations of thermodynamics.

Floyd Buckley

A substitution group for generating families of thermodynamic formulas is derived. The method of derivation is based upon the transformation properties of a "group of functions" under a contact transformation. There exists a characteristic function and a "group of functions" for each representation, that is, each coordinate system, and to each function of the group there is an associated contact transformation which transforms the group into its equivalent in another representation. The invariance of the functional form of the characteristic groups of functions under contact transformations is equivalent to invariance under a substitution group  $G$  on the space  $(EHFG)(V - S - TP)$ . The group  $G$  is independent of the representation and can be generated geometrically.

There are four contact transformations (including the identity) associated with each representation. These transformations are equivalent, and from them families of equations can be found which are invariant under the group  $G$ . Other families can be found among the transformation formulas for the higher derivatives.

Formulas deducible by simple operations, for example, differentiation, on the characteristic group of functions of a given representation provide basic forms for families invariant under the group  $G$ . The number of members in a family is 1, 2, 4, or 8. 21 p.

RP1606. Review of recent absolute determinations of the ohm and the ampers.

Harvey L. Curtie

In the decade preceding 1944 there were published the results of eight determinations of the absolute ohm and seven of the absolute ampere. These determinations were made in the national standardizing laboratories of England, France, Germany, Japan, and the United States. However, only preliminary results of some of the researches have been published, and one value of the absolute ampere was obtained in an experiment that was originally developed for another purpose. Hence to obtain the most probable values of the absolute ohm and ampere, it is necessary to ignore some of the published results and to consider some of those remaining as more reliable than others. A critical analysis has been prepared of each of the determinations, and this analysis has been used as a basis for weighting the results.

The most probable value of the absolute ohm is given by the relation

$$1 \text{ mean international ohm} = 1.000\,490 \text{ absolute ohms.}$$

The mean deviation from the mean of the results used in obtaining this value is only 14 parts per million. Further confirmation of the probability of this result is shown by the agreement with the results of two other recent compilers of the absolute-ohm determinations.

The most probable value of the absolute ampere is given by the relation

$$1 \text{ mean international ampere} = 0.999\,853 \text{ absolute ampere.}$$

The mean deviation from the mean of the three results used in obtaining this value is 3 parts per million. Other recent compilers, however, have given larger values, one, 27 parts per million larger, and the other, 119 parts per million larger. 20 p. 10c.

RP1607. Heats of combustion of eight normal paraffin hydrocarbons in the liquid state.....Edward J. Prosen and Frederick D. Rossini

The heats of combustion of *n*-pentane, *n*-hexane, *n*-heptane, *n*-octane, *n*-nonane, *n*-decane, *n*-dodecane, and *n*-hexadecane, in the liquid state, were measured with a bomb calorimeter. The samples of hydrocarbon were of known high purity, were inclosed in thin glass bulbs and placed in a platinum cup in the calorimetric bomb with purified oxygen at a pressure of 30 atm, and were ignited electrically with a wire fuse. The amount of reaction in each experiment was determined from the amount of carbon dioxide formed by the combustion. Tests were made for the presence of carbon monoxide and other products of incomplete combustion. The calorimeter system was calibrated with electrical energy.

From the experimental data were calculated the following values for the heat of combustion, at 25° C and constant pressure, of the liquid hydrocarbon in gaseous oxygen to form gaseous carbon dioxide and liquid water, with all the reactants and products in their thermodynamic standard reference states, in int. kj/mole: *n*-pentane, 3508.56 ± 0.77; *n*-hexane, 4162.34 ± 0.83; *n*-heptane, 4816.35 ± 0.87; *n*-octane, 5469.82 ± 1.05; *n*-nonane, 6123.90 ± 1.12; *n*-decane, 6777.47 ± 1.52; *n*-dodecane, 8085.20 ± 1.65; *n*-hexadecane, 10699.1 ± 2.8. The corresponding values in kcal/mole, obtained by using the factor 1/4.1833, are *n*-pentane, 838.71 ± 0.18;



*n*-hexane,  $994.99 \pm 0.20$ ; *n*-heptane,  $1151.33 \pm 0.21$ ; *n*-octane,  $1307.54 \pm 0.25$ ; *n*-nonane,  $1463.89 \pm 0.27$ ; *n*-decane,  $1620.13 \pm 0.36$ ; *n*-dodecane,  $1932.73 \pm 0.39$ ; *n*-hexadecane,  $2557.58 \pm 0.68$ . 18 p. 10c.

RP1608. Liquid-junction potentials, and relative activity coefficients of chloride ions, in concentrated mixed chlorides and nitrates at 25°C.

George G. Manov, Nicholas J. DeLollis, and S. F. Acree

Measurements are reported of the electromotive forces at 25°C of pairs of calomel half-cells in which portions of the saturated potassium chloride had been replaced at constant ionic strength (4.831) by hydrochloric acid and potassium nitrate. The method of cells with liquid junctions was used.

Data are given for the stability of half-cells prepared with these electrolytes, for the reproducibility of the liquid junction and the calculated value of its potential, and for the activity coefficient of the chloride ion in these mixtures relative to that of saturated potassium chloride solution. The addition of hydrochloric acid raises and the addition of potassium nitrate lowers the mean activity coefficient of chloride ion in potassium chloride solutions. Because the difference between the effective ionic mobilities for the cations and the anions in these solutions is smaller than in saturated potassium chloride alone, such cells are useful as reference electrodes in the reduction of the error caused by the neglect of the liquid-junction potential in the determination of pH by electrometric methods. 13 p. 10c.

RP1609. Ionization constant of boric acid and the pH of certain borax-chloride buffer solutions from 0° to 60°C.

George G. Manov, Nicholas J. DeLollis, and S. F. Acree

The ionization constant of boric acid was determined by the use of the electromotive force of cells without liquid junctions. Hydrogen and silver-silver-chloride electrodes were immersed in borax-sodium chloride solutions. To reduce the possibility of formation of polyborates, dilute solutions were used. The emf were measured at 5-degree intervals over the temperature range 0° to 60°C.

The negative common logarithm of the ionization constant (pK) of boric acid over the temperature range 0° to 60°C may be represented by the equation

$$pK = 2237.94/T + 0.016883T - 3.305,$$

where *T* is the absolute temperature.

The data indicate that the mean activity coefficients of the ions of sodium chloride and of sodium borate do not differ appreciably. The pH values for the solutions studies and for rounded values of the concentration are tabulated as functions of temperature and ionic strength. These solutions, which range in pH values from 8.934 to 9.465, can be used as standards in the calibration of glass-calomel and other electrometric pH equipment.

A discussion is given of the significance of the quantity *a*<sub>i</sub> (commonly called the "distance of closest approach" of the ions) and its importance in the calculation of pH values, especially when the buffer ion is not univalent.

The changes in free energy, heat content, entropy, and heat capacity that accompany the ionization of 1 mole of boric acid are listed. 20 p. 10c.

RP1610. Determination of tin in nonferrous metals by distillation as bromide and precipitation with cupferron.....William D. Mogerman

A gravimetric method is described for the determination of tin in copper-base and lead-base alloys. The procedure involves separation of the tin by distillation, precipitation with cupferron, and ignition to stannic oxide. Results obtained by applying the method to known amounts of tin and to a number of nonferrous alloys show that an accuracy to  $\pm 0.2$  mg can be expected for amounts of tin ranging 0.05 to 0.24 g. 8 p. 5c.

RP1611. Machines and methods for testing cordage fibers.....Herbert F. Schiefer

Machines are described for testing the flexural endurance and the resistance to abrasion of cordage fibers. In the test for flexural endurance, a bundle of fibers having a twist of one turn per inch is repeatedly drawn back and forth over three small pulleys located at the vertices of an isosceles right triangle. In the test for resistance to abrasion, a similarly twisted bundle of fibers is drawn back and forth against a second bundle twisted once around the first. This test is made in such a way that the flexing of fibers during the test is reduced to a minimum.

The procedures for the selection of fibers, preparation of fiber bundles weighing 5 grains per 15 inches of length, and conditioning of test specimens are outlined. The unprocessed fibers were tested for the following: Fineness of fiber; dry and wet breaking strength and elongation; flexural endurance; resistance to abrasion; and the



effect of elevated temperatures, continuous soaking in fresh and in salt water, alternate wetting and drying with fresh or salt water, and exposure to light with intermittent spraying with water. The results of tests of six lots of abaca, nine of sisal, two of jute, two of henequen, one of pita floja, one of ixtle, four of sanseveria, one of palmetto, three of hemp, two of roselle, one of manzanita, two of yucca, and one of malvita are given and discussed.

Great variations were found in the characteristics of different lots and grades of one kind of fiber. There was considerable overlapping in results of different kinds. No one kind of fiber was outstanding in all respects. Abaca was the strongest of the fibers tested, but some of the lots of abaca were weaker than some lots of sisal. Henequen and sisal were more resistant to abrasion than the other fibers tested, and they had higher flexural endurance, but were the least resistant to exposure to light and intermittent spraying with water. Pita floja, one of the strongest fibers tested, was one of the least resistant to abrasion. Sanseveria had exceptionally good strength. Hemp and jute were very similar in all of the characteristics measured. The resistance to abrasion of the fibers tested was profoundly affected by the direction of twist in the ply relative to that in the bundle, and also by the addition of a small amount of lubricant. 25 p. 15c.

RP1612. Thermal-density coefficients and hydrometer correction tables for vegetable tanning extracts.....Mary Grace Blair and Elmer L. Peffer

Densities and thermal expansions have been determined of the vegetable tanning extracts — quebracho, oak bark, hemlock bark, chestnut, and mangrove bark — within the range 1.00 to 1.12 specific gravity at 60°/60°F and over the temperature range 50° to 100°F. Thermal-density coefficients are presented in such a manner that the density of an extract at any temperature within the range can be calculated if its specific gravity at 60°/60°F or its density at 25°C is known. The information obtained has been used also in the preparation of tables for correcting hydrometer readings at observed temperatures in degrees barkometer, in degrees Twaddle, and in degrees Baumé to readings at the standard temperature 60°F. 11 p. 5c.

RP1613. Measurement of rate of flow of water through filter paper.

Herman Bogaty and Frederick T. Carson

A method is described for measuring the rate of filtration of water through filter papers, in which the paper is used as a cone in the usual manner and special apparatus is not required. An equation is derived, with which a water-filtration coefficient is determined from the filtration data. Data are presented also to show the effect of continued filtration on this coefficient. A correlation is shown between the air permeability of filter paper and the rate of filtration, enabling one to make a good estimate of the speed of a filter paper without wetting it. A definite procedure is recommended for determining the rate of flow of water through filter paper. 10 p. 5c.

RP1614. Attack of refractory platiniferous materials by acid mixtures at elevated temperatures.

Edward Wichers, William G. Schlecht, and Charles L. Gordon

Iridium and other refractory metals and alloys of the platinum group can be easily prepared for analysis, or for small-scale refining, by solution with hydrochloric acid and suitable oxidants in sealed tubes at temperatures up to 300°C. The effects on the rate of solution of iridium caused by variations in temperature, in concentrations of hydrochloric acid and of the oxidant, and in the nature of the oxidant, are reported. The rate increases rapidly with increase in temperature. It also increases with increasing concentration of hydrochloric acid, up to nearly anhydrous hydrogen chloride. With variation in the concentration of chlorine or equivalent oxidants, the rate passes through a maximum at a relatively low concentration.

A number of other factors of less importance are also discussed. Suitable working conditions for dissolving various alloys and minerals are suggested. 19 p. 10c.

RP1615. Improved reflux regulator and head for laboratory distilling columns.

Charles B. Willingham and Frederick D. Rossini

A reflux regulator and head for laboratory distilling columns is described that is an improvement over the one previously in use (see J. Research N. B. S. 23, 509 (1939) RP1249) in the distillation laboratory at the National Bureau of Standards in connection with the work of the American Petroleum Institute Research Project 6. The improvements are in better measurement of the temperature of the liquid-vapor equilibrium, in reduction of the hold-up, and in increase in the mechanical strength. 5 p.

RP1616. Preparation of salts of galacturonic acid from beet pulp.

Horace S. Isbell and Harriet L. Frush

This investigation demonstrates that dried beet pulp can be hydrolyzed by a commercial pectic enzyme, and that calcium galacturonate, sodium calcium galacturonate, and sodium strontium galacturonate can be obtained readily from the hydrolyzate. The crystalline salts are obtained by neutralization of the hydrolyzate with suitable bases, followed by concentration. Samples of dried beet pulp gave calcium galacturonate, sodium calcium galacturonate, and sodium strontium galacturonate in yields corresponding to 105 g, 227 g, and 255 g/kg, respectively.

It is also shown that sodium strontium galacturonate can be separated, at least in some cases, directly from silage drainage liquor. The occurrence of galacturonic acid in the drainage liquor suggests the possibility of developing a process in which hydrolysis is effected by organisms grown in beet pulp. 12 p. 5c.

RP1617. Preparation of sodium strontium galacturonate from citrus products.

Harriet L. Frush and Horace S. Isbell

The present paper describes the convenient separation of galacturonic acid in the form of sodium strontium galacturonate from the hydrolyzates of citrus products, namely pectic acid, pectin, and the peel of oranges and of grapefruit. The methods are suitable for the preparation of large or small quantities of the salt, and it is believed that the preparation from pectic acid is commercially practicable.

Sodium strontium galacturonate is obtained from pectic acid in about 90-percent yield without the use of alcohol or other organic solvent. By treatment of the salt with an equivalent quantity of aqueous sulfuric acid, a solution is obtained from which about 65 percent of the galacturonic acid may be crystallized in one crop, substantially pure. Additional crops obtained by the use of an organic solvent make the yield nearly quantitative.

Pectin is not quite so satisfactory in the process as pectic acid, but because of its educational value, the preparation of sodium strontium galacturonate from pectin might be included in a course of laboratory instruction to demonstrate the presence of galacturonic acid in pectic substances. Both orange peel and grapefruit peel may be used for the preparation of sodium strontium galacturonate, but the industrial use of these materials does not seem feasible at present on account of the large quantities of relatively expensive enzyme required for hydrolysis. 6 p. 5c.

RP1618. Standard response functions for protanopic and deuteranopic vision.

Deane B. Judd

The color matches set up by the normal observer can be predicted satisfactorily by three functions of wavelength defining the ICI standard observer. It has been found possible by a transformation of coordinate system to express these three functions in a form such that two of the three pairs also represent the color matches of the two recognized types of red-green-blind observer, the protanope and the deuteranope, within the rather small uncertainties to which they are known. The remaining pair of functions represents, within the comparatively large uncertainties to which they are known, the color matches of the tritanope, a more rare type of observer who confuses reddish blue with greenish yellow. These three functions, therefore, serve to relate the color matches made by dichromats to those made by normal trichromats, and so make conveniently accessible the color confusions of average dichromatic observers. The use of these three functions in the solution of problems arising in the design of tests for colorblindness is illustrated by solution of three such problems, and their connection to theories of color vision is discussed. 31 p. 10c.

RP1619. Some experimental data on the heats of combustion of benzoic acid and carbon (graphite).....Edward J. Prosen and Frederick D. Rossini

Some experimental data are reported on the heats of combustion of benzoic acid and carbon (graphite). The data on benzoic acid support the change in the value for its heat of combustion recently reported from this Bureau by Jessup. The data on carbon (graphite) yield a slightly higher value for the heat of formation of carbon dioxide than that previously reported. 8 p. 5c.

RP1620. Heat of formation of carbon dioxide and of the transition of graphite into diamond...Edward J. Prosen, Ralph S. Jessup, and Frederick D. Rossini

A recalculation of data previously reported on the heats of combustion of graphite and diamond, together with consideration of some new data on graphite, yielded the following selected "best" values for the heats of combustion of graphite and diamond and of the transition of graphite into diamond:



$C(c, \text{graphite}) + O_2(\text{gas}) = CO_2(\text{gas}); \Delta H_{298.16}^\circ = -393,447 \pm 45 \text{ int. j/mole} = -94,051.8 \pm 10.8 \text{ cal/mole}$   
 $C(c, \text{diamond}) + O_2(\text{gas}) = CO_2(\text{gas}); \Delta H_{298.16}^\circ = -395,343 \pm 96 \text{ int. j/mole} = -94,505.1 \pm 22.9 \text{ cal/mole.}$   
 $C(c, \text{graphite}) = C(c, \text{diamond}); \Delta H_{298.16}^\circ = 1896 \pm 85 \text{ int. j/mole} = 453.2 \pm 20.3 \text{ cal/mole. } 3 \text{ p. } 5c.$

RP1621. Preparing refractory oxides, silicates, and ceramic materials for analysis, by heating with acids in sealed tubes at elevated temperatures.

Edward Wichers, William G. Schlecht, and Charles L. Gordon

This paper describes the preparation for analysis of a number of refractory oxides, ceramic materials, and minerals by decomposition with hydrochloric or hydriodic acid at temperatures up to 300°C. All the oxides of the elements in the second, third, and fourth groups of the periodic system, with the exception of silica, titania, zirconia, and possibly hafnia, respond to the treatment. A number of silicate minerals, ordinarily difficult to prepare for analysis, are likewise successfully decomposed. 6 p. 5c.

RP1622. Use of sealed tubes for the preparation of acid solutions of samples for analysis, or for small-scale refining; pressures of acids heated above 100°C.

Charles L. Gordon, William G. Schlecht, and Edward Wichers

This paper describes special technics suitable for the use of sealed tubes in treating refractory materials with hydrochloric acid and other acid mixtures at elevated temperatures. Methods for filling, for sealing, and for opening tubes are discussed. The feasibility of reuse of tubes of Pyrex glass is discussed with some observed phenomena of the attack on the glass by the acids. A protecting shell is described together with a method of using solid carbon dioxide to provide the compensating pressures needed to protect the sealed tubes from bursting. The pressures developed on heating hydrochloric acid and mixtures of hydrochloric acid with nitric or perchloric acids were measured in a special gage, which is described. 14 p. 5c.

RP1623. Analogy of hydrated calcium silicoaluminates and hexacalcium aluminate to hydrated calcium sulfoaluminates. . . E. P. Flint and Lansing S. Wells

Two hydrated calcium silicoaluminates were prepared, which appear to be the silica analogs of the hydrated calcium sulfoaluminates. The low-silica compound has the formula,  $3CaO \cdot Al_2O_3 \cdot CaSiO_3 \cdot 12H_2O$ . It occurs as hexagonal plates, is uniaxial negative, and has the indices of refraction,  $\omega = 1.538$ ,  $\epsilon = 1.523$ . The other compound occurs as needle-shaped prisms and is uniaxial negative;  $\omega = 1.487$ ,  $\epsilon = 1.479$ . It was not obtained in pure form but, by analogy with other calcium aluminate complex salts, was tentatively assigned the formula,  $3CaO \cdot Al_2O_3 \cdot 3CaSiO_3 \cdot 30-32H_2O$ . The low-silica compound is slowly converted to the high-silica silicoaluminate on standing in contact with lime solutions. The high-silica compound was identified in mixtures of  $\beta\text{-}2CaO \cdot SiO_2$  and  $4CaO \cdot Al_2O_3 \cdot Fe_2O_3$ ;  $\beta\text{-}2CaO \cdot SiO_2$  and  $3CaO \cdot Al_2O_3$ ; and  $3CaO \cdot SiO_2$  and  $4CaO \cdot Al_2O_3 \cdot Fe_2O_3$  which had stood in contact with approximately saturated lime solution for 3 years. A hydrated hexacalcium aluminate,  $6CaO \cdot Al_2O_3 \cdot 33H_2O$ , was prepared. It occurs as long, needle-like prisms, is uniaxial negative, and  $\omega = 1.475$ ,  $\epsilon = 1.466$ . Its formula may be written as  $3CaO \cdot Al_2O_3 \cdot 3Ca(OH)_2 \cdot 30H_2O$ , which indicates that it is the compound formed when the  $CaSO_4$  in the high-sulfate sulfoaluminate is completely replaced by  $Ca(OH)_2$ . 8 p. 5c.

Title page and contents for volume 33. 6 p. 5c.

#### RESEARCH PAPERS FROM JOURNAL OF RESEARCH OF THE NATIONAL BUREAU OF STANDARDS, VOLUME 34, JANUARY—JUNE 1945

RP1624. Methods for measuring the coefficient of restitution and the spin of a ball. Lyman J. Briggs

Four methods for measuring the coefficient of restitution of a ball are discussed and employed experimentally. These methods are:

1. The two-pendulum ballistic method of Thomas, in which the ball is struck by a flat-nosed projectile driven from an airgun.
2. A method based on spark photography, by means of which the ratio of the speed of the ball to that of the projectile is determined.
3. The measurement of the vertical rebound of a ball from a massive horizontal plate, when dropped from a known height, correction being made for air resistance.
4. The measurement of the angle of reflection of a ball rebounding from a smooth inclined plate, the angle of incidence being known.

A correction for spin is necessary in method 4 if the plate is not ideally smooth. Methods are described for measuring the spin velocity, and an approximate method for computing the spin is given, provided the coefficient of restitution is known.



The variation of the coefficient of restitution of golf balls with impact speed and with temperature is experimentally determined, and a method for determining the time interval during which the ball remains in contact with the club is described.

The coefficient of restitution of a golf ball when hit hard is roughly 0.7; the corresponding value for a baseball of prewar construction is about 0.45. 23 p. 10c.

RP1625. Evaluation of the finish of a metal surface by a replica method.

Harry K. Herschman

A method for evaluating surface finish through the medium of a nearly transparent plastic replica of a surface is described. The method consists essentially in passing a narrow beam of light transversely through the moving replica onto a photoelectric cell. Variations in the geometric characteristics of the film, which are associated with the serrations of the surface reproduced, control the intensity of the light passing through the film and reaching the photocell at any instant. The fluctuations of intensity of the transmitted light cause a pulsating voltage in the cell circuit, which is recorded by an electronic voltmeter. This voltage increases with increased surface roughness. The evaluations obtained by this means are very promising. Results for different surface finishes are correlated with profile measurements of the surface determined with the microscope. 7 p. 10c.

RP1626. Wearing quality of some vegetable-tanned sole leathers.

Robert B. Hobbs and Ruth A. Kronstadt

The differences between the wearing qualities of vegetable-tanned commercial sole leathers are small, the difference between the best and worst of the 20 tannages studied amounting to less than 16 percent. Additional compression, similar to that given by heavy rolling, improved the wear 5 percent. The test also indicated that there is no significant difference in the wear of leather tanned from domestic and from frigorifico hides; that water-soluble material and grease are lost from soles in service, with the greatest loss being shown by water-soluble ash; that the "rubber" and "leather" abrasive machines are of little use in predicting the relative wearing qualities of tannages; and that the water-soluble content, firmness, and degree of tannage are useful in estimating the wearing quality. These conclusions are based on tests in service of about 500 pairs of soles, mostly at Camp Lee, Va. 19 p. 10c.

RP1627. Frequency meter for use with Geiger-Müller counter.

Leon F. Curtiss and Burrell W. Brown

An improved circuit is described for reading the rate of pulses from a Geiger-Müller counter. Based on the usual procedure of leveling and rectifying the pulses to charge a condenser, the improvements concern a bridge-type vacuum-tube voltmeter to read the voltage on the condenser and an arrangement to compensate parasitic potentials developed in the rectifier for the pulses. An adequate source of potentials from one small transformer is described, which renders the circuit useful in portable instruments. Particular care has been taken to design a circuit that is independent of the voltage of the alternating-current mains from which the circuit is operated. A modification of the circuit for rapidly decaying sources is also described. 6 p. 5c.

RP1628. Heats of formation and combustion of 1,3-butadiene and styrene.

Edward J. Prosen and Frederick D. Rossini

Values are given for the heats of formation from the elements, and for the heats of combustion, of 1,3-butadiene and styrene, in both the liquid and gaseous states, at 25°C. 5 p. 5c.

RP1629. Heats of combustion of benzene, toluene, ethylbenzene, *o*-xylene, *m*-xylene, *p*-xylene, *n*-propylbenzene, and styrene.

Edward J. Prosen, Roger Gilmont, and Frederick D. Rossini

The heats of combustion of benzene, toluene, ethylbenzene, *o*-xylene, *m*-xylene, *p*-xylene, *n*-propylbenzene, and styrene were measured with a bomb calorimeter. The following values were obtained for the heat of combustion, at 25°C and constant pressure, of the liquid hydrocarbon in gaseous oxygen to form gaseous carbon dioxide and liquid water, with all the reactants and products in their thermodynamic standard reference states, in international kilojoules per mole: Benzene,  $3267.09 \pm 0.43$ ; toluene,  $3909.31 \pm 0.49$ ; ethylbenzene,  $4564.09 \pm 0.72$ ; *o*-xylene,  $4552.10 \pm 1.02$ ; *m*-xylene,  $4551.10 \pm 0.62$ ; *p*-xylene,  $4552.09 \pm 0.91$ ; *n*-propylbenzene,  $5217.37 \pm 0.68$ ; styrene  $4394.14 \pm 0.82$ . With the factor 1/4.1833, the corresponding values in kilocalories per mole are benzene, 780.93  $\pm$  0.10; toluene, 934.50  $\pm$  0.12; ethylbenzene, 1091.03  $\pm$  0.17; *o*-xylene, 1088.16  $\pm$  0.24; *m*-xylene, 1087.92  $\pm$  0.15; *p*-xylene, 1088.16  $\pm$  0.22; *n*-propylbenzene, 1247.19  $\pm$  0.16; styrene, 1050.40  $\pm$  0.20. 7 p. 5c.

RP1630. Panel tests for thermal spalling of fire-clay bricks used at high temperatures.....R. A. Heindl and W. L. Pendergast

Fifty brands of fire-clay brick, of which 16 were of the super duty, 28 of the high heat duty, and 6 of the intermediate heat duty classes, were tested for resistance to spalling by the standard method of the American Society for Testing Materials. Variations from the standard panel of brick in stretcher construction were made by laying brick as headers only, and also in combinations of stretchers and headers. The relation of gas pressure in the conditioning, or preheating, furnace, within the range 0.2 to 0.6 inch of water, to the spalling of firebrick was also investigated. The stability of volume and change in absorption resulting from reheating new specimens at 1,600°C for 5 hours under conditions of controlled gas pressure were determined of all the brands of the super duty class of brick as well as of 10 brands of the high heat duty class, the latter being reheated at 1,400°C only. The relation between the spalling loss by gravity only and after scraping with a trowel was investigated, as was also the relation between the spalling loss and the number of joints in the brick panel. 24 p. 15c.

RP1631. Application of the Ilkovič equation to quantitative polarography.

Floyd Buckley and John Keenan Taylor

Conditions of applicability of the Ilkovič equation to polarographic analysis were investigated for representative ions singly and in mixtures. Gelatin was used to suppress maxima found in current-voltage curves.

Results obtained with a capillary of usual characteristics showed that a suppresser is necessary to secure agreement with the Ilkovič equation over any considerable drop-time range, and that the need increases with the drop-rate of the electrode and the dilution of reducible ion. A criterion of diffusion control satisfactory for classification of polarograms by visual examination was found. The application of the Ilkovič equation to quantitative analysis was shown to be inadvisable unless it is definitely established that the experimental conditions are well within the range for insuring diffusion control. A logarithmic relation between critical drop-time and suppresser concentration was found. 18 p. 10c.

RP1632. Comparative liquid-junction potentials of some pH buffer standards and the calibration of pH meters.

George G. Manov, Nicholas J. DeLollis, and S. F. Acree

By application of the equation  $pH = (E - E_{ref} - E_j)/k$  to solutions whose pH values were known accurately, the sum of the potentials of the reference electrode and of the liquid-junction potential,  $E_{ref} + E_j$ , was obtained at 25°C by the method of cells with liquid junction for seven solutions suitable for standards of pH. The solutions used were 0.1018-*m* hydrochloric acid, pH 1.081; 0.01-*m* hydrochloric acid + 0.09-*m* sodium chloride, pH 2.101; 0.05-*m* potassium acid phthalate + 0.02-*m* potassium chloride, pH 3.989; 0.02-*m* potassium dihydrogen phosphate + 0.02-*m* disodium hydrogen phosphate + 0.02-*m* sodium chloride, pH 6.863; 0.02-*m* potassium phenolsulfonate + 0.02-*m* potassium sodium phenolatesulfonate + 0.02-*m* sodium chloride, pH 8.795; 0.02-*m* boric acid + 0.02-*m* sodium borate (added together as sodium tetraborate) + 0.02-*m* sodium chloride, pH 9.155; and 0.01727-*m* calcium hydroxide + 0.01819-*m* sodium chloride, pH 12.38. Silver-silver-chloride electrodes immersed in saturated potassium chloride solution were used rather than the calomel electrodes customarily employed.

As  $E_{ref}$  remains constant when the buffer is changed, values for the differences in the liquid-junction potentials of various buffers in contact with saturated potassium chloride solution were obtained from the data. These differences were then used to calibrate seven Type 015 and three "low-alkali error" glass electrodes of commercial manufacture. The average agreement between the true pH of the buffer-chloride solution (determined from cells without liquid junctions) and that read on various commercial pH meters when corrected for the difference in the liquid-junction potentials and the alkali error of the electrode was  $\pm 0.01$  pH unit. The data also furnish a critical test of the consistency of the pH values assigned to the various buffer solutions recommended by this Bureau for the calibration of the pH scale and for checking pH meters.

Recommendations are made for checking pH meters. 13 p. 5c.

RP1633. Spectrographic determination of sodium, potassium, and lithium in portland cement with the direct-current carbon arc.....Armin W. Helz

Spectrographic methods, which are much less time-consuming than the usual chemical methods, are described for the determination of sodium, potassium, and lithium in portland cement. For the determination of sodium and potassium the sample is mixed with a mineral base containing silver for the internal standard.

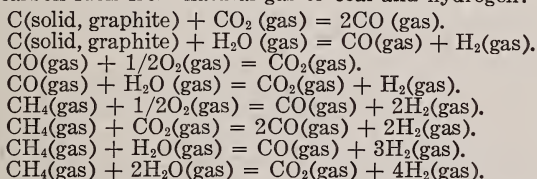


For lithium a standard mixture of graphite and strontium carbonate is added to the cement sample. In either case a fixed amount of the resultant mixture is placed in the crater of a graphite electrode, which is made the lower positive element of a direct-current arc. The Na 8194.81 Å, K 7698.98 Å, and Li 3232.61 Å lines are used for the quantitative calculations. A discussion of the development of the method is given, followed by details of the adopted analytical procedure. The spectrographic analyses of 41 cements for sodium and potassium are given for comparison with the chemical values. 14 p. 10c.

RP1634. Heats, free energies, and equilibrium constants of some reactions involving  $O_2$ ,  $H_2$ ,  $H_2O$ , C, CO,  $CO_2$ , and  $CH_4$   
Donald D. Wagman, John E. Kilpatrick, William J. Taylor, Kenneth S. Pitzer, and Frederick D. Rossini

Values are presented for the following thermodynamic properties: The heat-content function,  $(H^\circ - H_0^\circ)/T$ , the free-energy function,  $(F^\circ - H_0^\circ)/T$ , the entropy,  $S^\circ$ , the heat content,  $H^\circ - H_0^\circ$ , and the heat capacity,  $C_p^\circ$ , for  $O_2$  (gas) to 5,000 °K,  $H_2$  (gas) to 5,000 °K,  $H_2O$  (gas) to 3,000 °K,  $N_2$  (gas) to 5,000 °K, C (solid, graphite) to 1,500 °K, C (solid, diamond) to 1,200 °K, CO (gas) to 5,000 °K,  $CO_2$  (gas) to 3,500 °K, and  $CH_4$  (gas) to 1,500 °K; the standard entropy,  $S^\circ$ , for  $H_2O$  (liq) at 25 °C; the heat of formation,  $\Delta H_f^\circ$ , the free energy of formation,  $\Delta F_f^\circ$ , and the equilibrium constant of formation,  $K_f$ , from the elements, for  $H_2O$  (liq) at 25 °C, and for  $H_2O$  (gas), CO (gas),  $CO_2$  (gas), and  $CH_4$  (gas), to 1,500 °K; the increment in heat content,  $\Delta H^\circ$ , and the increment in free energy,  $\Delta F^\circ$ , for the transition of graphite into diamond, to 1,200 °K and to 20,000 atmospheres.

From the foregoing, values were calculated for the increment in heat content,  $\Delta H^\circ$ , the increment in free energy,  $\Delta F^\circ$ , and the equilibrium constant,  $K$ , for the following reactions, most of which are important in connection with the production of liquid hydrocarbon fuels from natural gas or coal and hydrogen:



A table of the fundamental constants used in the calculations is given. 18 p. 10c.

RP1635. Heats of isomerization of the 18 octanes.  
Edward J. Prosen and Frederick D. Rossini

The heats of isomerization of all of the 18 octanes were determined by measurement of the ratios of their heats of combustion, in the liquid state for 17 and the solid state for 1, using the procedure previously described for the hexanes and the heptanes.

Values of the heats of isomerization are reported for the condensed (liquid or solid) state at 25°C and for the gaseous state at 25°C and 0°K. 12 p. 5c.

RP1636. Region of usable imagery in airplane-camera lenses... Francis E. Washer

The proper positioning of a lens with respect to the focal plane in a fixed-focus camera, such as an airplane-mapping camera, is governed by several factors that relate to the optical qualities of the lens. These factors are quality of imagery, depth of focus at a given stop opening, and curvature of field. This investigation shows that there is reasonably good agreement between observed depth of focus at a given stop opening and that predicted on the basis of geometric optics. Observed values of the maximum resolving power at various angular separations from the axis are generally lower at the larger stop openings than values predicted on the basis of physical optics. This lowering is doubtless a consequence of residual aberrations, inherent in an actual lens, which are more noticeable at large aperture ratios. A method of presenting the resolving power characteristics throughout the range of useful imagery in the form of sets of master curves has been developed. These curves show at a glance the variation of resolving power with distance from the plane of best axial imagery, the depth of focus for any observed value of the resolving power, the effect of field curvature on imagery in any given image plane, and the differing performance for tangential and radial imagery at various angular separations from the axis. Successive groups of these master curves show how variations in stop opening affect the performance of a lens. 23 p. 10c.



RP1637. Relaxation of stresses in annealing glass. . . . . Arthur Q. Tool

An empirical equation representing relaxation of stresses in annealing glass is derived. Although the derivation is based on Maxwell's equation for viscous flow, consideration is also given to the changing viscosity as a glass anneals at a constant temperature. This new equation has been applied to data that were obtained by Adams and Williamson on the relaxation of stresses in annealing glass at various temperatures. It is shown that this equation applies very satisfactorily to their data. Also, it appears to be much more suitable than the reciprocal relation which these authors proposed as a substitute for the wholly unsatisfactory exponential relation that is derived directly from Maxwell's equation. This exponential relation is unsatisfactory simply because it does not take into account the changing viscosity of annealing glass. Finally, the new equation leads to a clearer understanding of the nature and behavior of glass because it does not neglect the change in viscosity. 13 p. 5c.

RP1638. Copper reduction of dextrose, levulose, invert sugar, and sucrose-invert-sugar mixtures in citrate-carbonate solution.

Richard F. Jackson and Emma J. McDonald

The copper reduction values for dextrose, levulose, invert sugar, alone and in the presence of sucrose, have been determined, employing a modified Benedict's copper citrate-carbonate reagent and the iodometric titration method of Shaffer and Hartmann. It has been found that under carefully controlled conditions this method is inferior with respect to precision to the methods of Munson and Walker and of Lane and Eynon, in which caustic alkali is a constituent of the copper reagent. Because of its convenience, it is valuable for rapid work where a precision not greater than 0.5 percent is required.

A table of equivalents for use in routine sugar analysis has been computed. 14 p. 5c.

RP1639. Effect of aeration on hydrogen-ion concentration of soils in relation to identification of corrosive soils. . . . . Melvin Romanoff

Soils are generally air-dried to obtain comparable results in the measurement of pH. This paper points out the unreliability of such a procedure in measuring the pH of soils for the identification of corrosive areas. Large changes were observed in hydrogen-ion concentration of a poorly drained soil in passing from the moist field condition to the air-dried state and vice versa. This suggested a further investigation, and 62 air-dried soil samples taken from the National Bureau of Standards soil-corrosion test sites were saturated and stored without air for almost 1 year. Significant changes in pH were observed in the majority of the samples and large changes in many of them. It has been concluded that, for the identification of areas corrosive to iron and steel, pH measurements of soils should be made on samples maintained in the natural field condition. 15 p. 5c.

RP1640. Specific heats of gaseous 1,3-butadiene, isobutene, styrene, and ethylbenzene. . . . . Russell B. Scott and Jane W. Mellors

This paper describes a flow calorimeter and measurements of the specific heats of four hydrocarbons that are of interest in connection with synthetic rubber. The measurements on gaseous 1,3-butadiene and isobutene cover the range  $-35^{\circ}$  to  $+80^{\circ}\text{C}$ . The specific heats of styrene vapor and ethylbenzene vapor were determined at  $100^{\circ}\text{C}$ . The calorimeter was tested by measuring the specific heat of normal hydrogen. The results on the hydrocarbons are believed to be correct to  $\pm 0.5$  percent. 12 p. 5c.

RP1641. Free energies and equilibria of isomerization of the 18 octanes.

Edward J. Prosen, Kenneth S. Pitzer, and Frederick D. Rossini

Values of the following thermodynamic properties are presented in tabular and graphical form for the 18 octanes in the ideal gaseous state, for the range  $298^{\circ}$  to  $1,000^{\circ}\text{K}$ : (a) the standard free energy of isomerization divided by the absolute temperature,  $\Delta F^{\circ}/T$ ; and (b) the relative amounts of the several isomers present in equilibrium with each other. 7 p. 5c.

RP1642. Heats of combustion and formation of the paraffin hydrocarbons at  $25^{\circ}\text{C}$ .

Edward J. Prosen and Frederick D. Rossini

Selected "best" values are given for the heats of combustion (in oxygen to form gaseous carbon dioxide and liquid water) and the heats of formation (from the elements solid carbon, graphite, and gaseous hydrogen) for methane and ethane in the gaseous state, and for all the paraffin hydrocarbons from propane through the octanes and the normal paraffins through eicosane, in both the liquid (except for one octane which is solid) and gaseous states, all at  $25^{\circ}\text{C}$ . Equations are given for calculating values for all the normal paraffins above eicosane. 7 p. 5c.

RP1643. Comparison of the purity of samples of organic solvents by ultraviolet spectrophotometry. . . Marion E. Maclean, Priscilla J. Jencks, and S. F. Acree

Studies of the uniformity of different samples of organic solvents by ultraviolet spectrophotometry are described. The procedure used is applicable to the detection of impurities originally present or formed by deterioration and to the study of the effectiveness of purification procedures.

Absorption curves are given for *n*-heptane, 2,2,4-trimethylpentane, cyclohexane, methylcyclohexane, decahydronaphthalene, benzene, carbon tetrachloride, methyl alcohol, ethyl alcohol, ethyl acetate, and dioxane, in two or more grades of purity. The absorption curves of tetrahydronaphthalene, toluene, xylene, chlorobenzene, ethylene dichloride, trichloroethylene, acetone, dimethyldioxane, and carbon bisulfide are discussed briefly. The effect of filtration through silica gel on the ultraviolet absorption of several commercial solvents is shown. 10 p. 5c.

RP1644. Vapor pressure, latent heat of vaporization, and triple-point temperature of  $\text{N}_2\text{O}$ . . . . . Harold J. Hoge

The vapor pressure of  $\text{N}_2\text{O}$  has been measured from the triple point ( $T = 182.351^\circ\text{K} = -90.809^\circ\text{C}$ ,  $p = 658.9$  mm Hg) to  $236^\circ\text{K}$  ( $p = 10.25$  atm). The data are compared with previous work in a graph that includes the entire liquid range.

The latent heat of vaporization was measured from the triple point to  $205^\circ\text{K}$ . At the boiling point ( $184.695^\circ\text{K} = -88.465^\circ\text{C}$ ) the latent heat is  $16.55$  kJ mole $^{-1}$ . The consistency of the data was tested with Clapeyron's equation, which was also used to compute latent heats above the range of the direct measurements. 12 p. 5c.

RP1645. Methods of polishing steel and their effects upon the protective value of electroplated coatings. . . . . Gerald A. Lux and William Blum

To determine whether the "finish" of steel prior to electroplating affects the protective value of the plated coatings, strips of cold-rolled steel were polished with wheels to which abrasives of different grain size were glued. The resultant finishes were measured with a Profilometer and were expressed as root mean square, in microinches (millionths of an inch) of the departure of the contours from a plane surface. The finishes varied from a "superfinish," with root mean square of less than 1 microinch to 65 microinch, produced with a 90-grain abrasive. The weight (and average thickness) of steel removed by polishing was measured.

The polished specimens were plated with copper, nickel, and chromium of controlled thickness, and were exposed to the atmosphere at New York, N. Y.; Sandy Hook, N. J.; and Washington, D. C. The extent of rusting observed at periodic inspections was expressed on a numerical scale, and the average results over a period such as 1 year were expressed as "Percentage scores."

Comparison of these scores showed that wide differences in the surface finish of the steel had no significant effects on the protective value of the plated coatings. It is possible that use of hot-rolled steel, which is more likely to contain foreign inclusions, would have yielded differences as a result of polishing.

Results with accelerated tests, such as the salt spray, hot water, ferroxyl, and condensation tests, were not as reproducible and consistent as the atmospheric tests. 30 p.

RP1646. Photometer for luminescent materials. . . . . Ray P. Teele

In evaluating the usefulness of luminescent materials it is necessary to take into account the behavior of the human eye at low values of luminance. A photometer that provides for the determination of low luminances, with due regard for the characteristic behavior of the eye at such values, is described. It is interesting to note that both the luminescent materials and some of the phenomena of vision for the nearly dark-adapted eye have been known for many years, although the use of modern lamps to produce higher and higher illuminations has made it generally unnecessary to consider these phenomena. However, the use of the airplane for bombing with the countermeasure of blacking out as a means of passive defense and the need for markers in the interiors of blacked-out ships have shown many of the luminescent materials to be practical instead of merely novel, and has led to the development of methods for measuring the luminances they yield. 8 p. 5c.

RP1647. Freezing temperature of benzoic acid as a fixed point in thermometry.

Frank W. Schwab and Edward Wichers

The freezing temperature of benzoic acid is found to be reproducible with a precision comparable to that of the ice point and somewhat superior to that of the steam point as usually observed in standardizing laboratories. For use in the calibration of thermometric instruments the acid is contained in a partially evacuated glass cell provided with a thermometer well. When thus confined, and if not heated excessively,



the substance maintains a constant composition for long periods of time. When properly manipulated, the acid in a given cell exhibits a freezing temperature reproducible from day to day within 1 millidegree.

The triple point of pure benzoic acid is  $122.362^\circ \pm 0.002^\circ\text{C}$ . Under a pressure of 1 atmosphere of dry air the freezing temperature is 0.013 degree higher. Corresponding elevations for oxygen and nitrogen are 0.001 and 0.015 degree, respectively. The pressure coefficient of the freezing temperature is 0.039 degree/atm. The change in volume of the acid on freezing is  $-0.138\text{ cm}^3/\text{g}$ . The corresponding calculated value for the density of the solid at the freezing temperature is  $1.27\text{ g/cm}^3$ . The solubility of oxygen in the liquid at its freezing temperature, under a pressure of 1 atm., is  $0.132\text{ g/1,000 g of acid}$ ; that of nitrogen is  $0.073\text{ g}$ .

An appendix deals with a method of calculating temperatures, in the ranges  $-190^\circ$  to  $0^\circ\text{C}$  and  $0^\circ$  to  $660^\circ\text{C}$ , from observations with a platinum thermometer. For this purpose power-series equations are used instead of the Callendar and Callendar-Van Dusen equations. Tables are included to facilitate the computation of temperature. 40 p. 10c.

RP1648. pH of aqueous mixtures of potassium dihydrogen phosphate and disodium hydrogen phosphate at  $0^\circ$  to  $60^\circ\text{C}$ . Roger G. Bates and S. F. Acree

A method is suggested for computing the pH of phosphate buffers from electromotive-force measurements of cells without liquid junction. Each of the 33 buffer solutions studied was prepared from equal molal quantities of potassium dihydrogen phosphate and disodium hydrogen phosphate. The solutions were divided into five series with respect to the amount of sodium chloride added. The ratios of the molality of each buffer salt to that of sodium chloride in the five series were about 1, 2, 3, 8, and 10. The pH values were computed from measurements of cells with hydrogen electrodes and silver-silver-chloride electrodes by a procedure that involves extrapolation of a function of the emf to zero concentration of sodium chloride.

The values of the second dissociation constant of phosphoric acid given in an earlier paper (RP1524) were confirmed. The mean values of  $pK$ , the negative of the common logarithm of the second dissociation constant, are given as a function of absolute temperature,  $T$ , by the equation

$$pK = 2073.0/T - 5.9884 + 0.020912T$$

between  $T = 273.16$  and  $T = 323.16$  ( $0^\circ$  to  $50^\circ\text{C}$ ). Equations are given to express the change of pH with molality of sodium chloride. The pH values from  $0^\circ$  to  $60^\circ\text{C}$  of eight phosphate buffers without chloride are listed. The densities of the buffers were determined. At  $25^\circ\text{C}$ , the pH of buffers containing equal molal quantities of potassium dihydrogen phosphate and of disodium hydrogen phosphate is given by the equations

$$\text{pH} = 7.162 + 2.18 m - 2.237 \sqrt{m}$$

and

$$\text{pH} = 7.169 + 2.39 c - 2.324 \sqrt{c},$$

where  $m$  and  $c$ , the molality and the molar concentration of each buffer salt, lie between 0.005 and 0.1. 22 p. 10c.

RP1649. Melting point of alpha-alumina....R. F. Geller and P. J. Yavorsky

Results are given of seven melting-point determinations on alpha-alumina of high purity in an oxidizing atmosphere and under atmospheric pressure. There was detectable contamination of the specimens by vapors of other elements in the furnace atmosphere, but the results are believed to show that the melting point of alpha-alumina is within the range  $2,000^\circ$  to  $2,030^\circ\text{C}$ . 7 p. 5c.

RP1650. Heats and free energies of formation of the paraffin hydrocarbons, in the gaseous state, to  $1,500^\circ\text{K}$ .

Edward J. Prosen, Kenneth S. Pitzer, and Frederick D. Rossini

Values are presented for the heats of formation and the free energies of formation, from solid carbon (graphite) and gaseous hydrogen, of all the normal paraffin hydrocarbons and of the isomeric paraffins from the butanes through the octanes, in the gaseous state, to  $1,500^\circ\text{K}$ . 9 p.

RP1651. Method for calculating the properties of hydrocarbons and its application to the refractive indices, densities, and boiling points of the paraffin and monoolefin hydrocarbons.

William J. Taylor, Joan M. Pignocco, and Frederick D. Rossini

A method is described for calculating the properties of hydrocarbons which involves the summation of contributions from component parts of the molecule, together with contributions from interactions between adjacent component parts.



For the paraffin hydrocarbons, the calculations were made in terms of the difference in the value of the property between a given normal paraffin and its isomers, and the required constants were evaluated from data on 33 paraffins,  $C_5$  to  $C_8$ . For these paraffins, the average deviation of the calculated from the experimental values is  $\pm 0.00074$  g/ml in density,  $\pm 0.00042$  in refractive index ( $n_D$  at  $20^\circ C$ ), and  $\pm 0.55^\circ C$  in the normal boiling point.

In the case of the monoolefin hydrocarbons, the calculations were made in terms of the difference in the value of the property between a given monoolefin and the corresponding paraffin having the same carbon skeleton, and the required constants were evaluated from data on 58 monoolefins,  $C_5$  to  $C_7$ . For these monoolefins, the average deviation of the calculated from the experimental values is  $\pm 0.0031$  g/ml in density,  $\pm 0.0020$  in refractive index ( $n_D$  at  $20^\circ C$ ), and  $\pm 1.33^\circ C$  in the normal boiling point. 22 p. 10c.

RP1652. Separation and determination of aromatic and monoolefin hydrocarbons in mixtures with paraffins and naphthenes by adsorption.

Beveridge J. Mair

A new method is described for separating and determining aromatic and monoolefin hydrocarbons in mixtures with paraffins and naphthenes by adsorption. The mixture to be analysed is introduced into the top of a column of silica gel and, when the liquid level just reaches the top of the silica gel, a suitable desorbing liquid, such as ethyl alcohol, is added. The desorbing liquid forces the hydrocarbon portion down the column, during which passage the hydrocarbon portion is fractionated according to the adsorbability of the various components. These components issue from the bottom of the column in the following order: Paraffin plus naphthene, monoolefin, and aromatic hydrocarbons. The analysis is made by determining the fraction of the total volume constituted by each of these classes.

Results of the analyses of five solutions containing aromatic and paraffin hydrocarbons, and three solutions containing aromatic, monoolefin, and paraffin hydrocarbons are given. A procedure is outlined for determining the aromatic content of a straight-run petroleum distillate, as in the gasoline or kerosine fractions. 18 p. 10c.

RP1653. Methods for the evaluation of analytical filter papers.

B. W. Scribner and W. K. Wilson

As part of an investigation of analytical filter papers for the purpose of assisting in the development of standards of quality, improved methods for rate of flow of water, retention of fine precipitates, and determination of ash were developed. The use of complicated apparatus for measuring the rate of flow of water was avoided by applying Darcy's law to the ordinary conical filter. The use of prefiltered water in making the measurement was found necessary for satisfactory reproducibility. As the standard method for determining the ash content of paper is not sufficiently accurate for filter paper, the method was modified in that a tare crucible is used and the test specimen wetted and pressed into a compact wad to permit the use of as small a crucible as possible.

The other tests were bursting strength of wet paper, thickness, weight per unit area, alpha cellulose, copper number, and acidity (pH). The last three named are of importance relative to the purity of the cellulose and the stability of acid-washed papers, as instances of deterioration of the cellulose of such papers have been observed. Action of acid results in brittling of the papers and in the formation of modified forms of cellulose that are soluble in some solutions. 7 p. 5c.

RP1654. Intrinsic viscosities and osmotic molecular weights of cellulose acetate fractions.....Arnold M. Sookne and Milton Harris

The intrinsic viscosities and osmotically estimated number-average molecular weights of a series of cellulose acetate fractions have been measured. It was found that within the range of chain lengths investigated (number-average molecular weight,  $\bar{M}_n$ , up to 130,000) the number-average molecular weights are proportional to the intrinsic viscosities in acetone solutions, in agreement with Staudinger's rule and the results of Kraemer. An estimate is provided of the relative homogeneity with respect to molecular size of the fractions and the starting material from which they were prepared. 8 p. 5c.

RP1655. Polymolecularity and mechanical properties of cellulose acetate.

Arnold M. Sookne and Milton Harris

The tensile strengths, ultimate elongations, and folding endurances of films prepared from a series of cellulose acetate fractions and blends were studied. When the mechanical properties are plotted against the intrinsic viscosities (or relative weight-average degrees of polymerization), the results for the fractions and different blends fall on separate curves. In contrast, when the mechanical properties are plotted against

the number-average degrees of polymerization, the results for the fractions and all of the blends fall approximately on a single curve for each property. The results are shown to be qualitatively consistent with the hypothesis that the mechanical properties of blends are the weight-averages of the properties of their components. The results emphasize the importance of the determinations of the number-average degree of polymerization in studying commercial polymolecular materials. 10 p. 5c.

RP1656. Term analyses of the first two spectra of columbium.

Curtis J. Humphreys and William F. Meggers

Published wavelengths and estimated intensities of lines characterizing the first two spectra of columbium (RP881) have been supplemented by observations of the arc spectrum (6500 to 8500 Å) in an atmosphere of helium, by observations of the spark spectrum (2000 to 2100 Å), and by measurements of the Zeeman patterns for 1,557 lines. All available data have been analyzed for the purpose of correcting and extending the information about the structures of Cb II and Cb I (RP793).

The Cb II table contains 1,723 lines (2002.41 to 7026.15 Å), 1,494 of which are explained as combinations of 183 ionic energy levels comprising 27 singlet, 40 triplet, and 9 quintet spectral terms. The terms arising from electron configurations  $4d^4$ ,  $4d^3 5s$ , and  $4d^3 5p$  have been almost completely established, but efforts to find spectral series for Cb II were futile. The lowest energy (normal state) of  $Cb^+$  ions is represented by  $(4d^4) a^5D_0$ , but the strongest emission lines involve  $(4d^3 5s) a^5F_5$ , a metastable term. The most intense line of the Cb II spectrum is  $(4d^3 5s) a^5F_5 - (4d^3 5p) z^5G_5^o$ , with a wavelength of 3094.172 Å. Zeeman patterns observed for 646 Cb II lines were most helpful in extending this analysis, which now includes 87 percent of the recognized lines and 95 percent of their total intensity.

The Cb I table contains 3,313 lines (2164.54 to 10920.7 Å), 2,836 of which have been interpreted as combinations of 364 atomic energy levels representing 58 doublet, 55 quartet, and 13 sextet spectral terms. The lowest term (normal state of neutral Cb atoms is  $(4d^4 5s) a^6D_{5/2}$ , and the strongest line of the Cb I spectrum is the transition  $(4d^4 5s) a^6D_{5/2} - (4d^3 5p) y^6F_5^{3/2}$ , with a wavelength of 4058.931 Å. The Cb I spectrum is largely accounted for by transitions between levels arising from  $4d^4 5s$  or  $4d^3 5s^2$  and  $4d^4 5p$  or  $4d^3 5s5p$  electron configurations. Zeeman patterns measured for 911 Cb I lines have been 90 percent interpreted in this analysis, which now includes 86 percent of the known lines and over 93 percent of their intensity. Two members of the series  $(4d^4 ns) ^6D$  and two each of  $(4d^3 5s np) ^4(DFG)$  have been established. Extrapolation of these indicates a limit of 54,600  $cm^{-1}$ , which represents the energy difference between the normal states of Cb atoms and  $Cb^+$  ions. The corresponding ionization potential for neutral columbium atoms is 6.77 volts. 109 p. 25c.

RP1657. Diamond cutting accelerated by an electric arc.

Chauncey G. Peters, Karl F. Nefflen, and Forest K. Harris

The method universally employed for cutting plane surfaces or facets on diamonds has been to place the diamond in contact with a flat cast-iron lap charged with diamond powder and rotated at about 2,000 revolutions per minute. In the work described in this paper it was found that by producing a high-voltage electric arc at the contact between the diamond and the lap, the cutting rate is materially increased for all orientations of the diamond, and good progress can be made directly on a natural octahedron face, where cutting without the arc is almost impossible.

By applying the arc to a diamond saw the sawing rate is greatly increased, and diamonds can be sawed regardless of the orientation of the cut relative to the crystal axes. 7 p. 10c.

RP1658. A transfer strain gage for large strains.

Martin Greenspan and Leroy R. Sweetman

A simple strain gage, suitable for measurement of strains of from - 16 to + 32 percent on a 1.5-inch gage length, is described. 3 p. 5c.

RP1659. Refractive-index standards of fluorocrown glass. . . . . Leroy W. Tilton

Refractive-index samples of fluorocrown glass, which provide solid standards in the index range between fused quartz,  $n_D = 1.458$ , and low index silicate crown glass,  $n = 1.51$ , are characterized by very low temperature coefficients of index, and thus are especially recommended for use at extreme room temperatures. The calibration of such standards may be facilitated by comparisons with the precise data herein tabulated for six of these glasses in the temperature range 15° to 55°C. Because of surface weathering, repolishings are sometimes necessary to avoid hazy and possibly false critical border lines. In some cases bright bands appear in the dark portion of the refractometer field. These are interpreted as critical-angle phenomena corresponding to decomposition products in the surface layers. 10 p. 5c.

Title page and contents for volume 34. 7 p. 5c.



RP1660. Single-cylinder engine tests of substitute motor fuels. . . . Donald B. Brooks

Single-cylinder-engine tests of nonhydrocarbon fuels and gasoline, at fixed compression ratio and at the compression ratio for trace knock for each fuel, show no material differences in performance other than those associated with differences in heats of combustion and vaporization. All the nonhydrocarbon fuels could be operated at compression ratios higher than was permissible with the gasoline, with corresponding increases in power and thermal efficiency. 37 p. 10c.

RP1661. Thermodynamic properties of 1,3-butadiene in the solid, liquid, and vapor states.

Russell B. Scott, Cyril H. Meyers, Robert D. Rands, Jr., Ferdinand G. Brickwedde, and Norman Bekkedahl

This paper presents a detailed description of apparatus used and the results obtained in the following measurements relating to the thermodynamic properties of 1,3-butadiene in the solid, liquid, and vapor states: (1) Specific heats from  $-258^{\circ}$  to  $+30^{\circ}\text{C}$ , (2) heat of fusion, (3) heats of vaporization from  $-26^{\circ}$  to  $+23^{\circ}\text{C}$ , (4) vapor pressures from  $-78^{\circ}$  to  $+110^{\circ}\text{C}$ , (5) liquid densities from  $-78^{\circ}$  to  $+95^{\circ}\text{C}$ , (6) vapor densities from  $30^{\circ}$  to  $150^{\circ}\text{C}$ , and (7) the critical pressure, volume, and temperature of 1,3-butadiene. Tables embodying the results of these measurements are included for specific heats, enthalpy, and entropy of the solid, liquid, and vapor. 48 p. 10c.

RP1662. Effects of some oxide additions on the thermal length changes of zirconia.

R. F. Geller and Paul J. Yavorsky

The oxides of cerium, yttrium, silicon, magnesium, and calcium were added in various proportions to zirconia of 99-percent purity, and the effects of these additions, combined with preheating at various temperatures ranging from  $1,450^{\circ}$  to  $1,950^{\circ}\text{C}$ , on thermal length changes of the zirconia during heating and cooling between room temperature and a maximum of  $1,700^{\circ}\text{C}$  were observed. The results are compared with similar observations on zirconia of 96-, of 98-, and of 99-percent purity without oxide additions.

The results show that the irregular thermal length changes accompanying phase transformations in zirconia may be prevented by changing the crystal to the stable cubic form. This was accomplished by (a) 11.5- and 15-percent additions of  $\text{Y}_2\text{O}_3$  and heating at  $1,700^{\circ}\text{C}$  or higher; (b) 8- and 15-percent additions of  $\text{MgO}$  and heating at  $1,550^{\circ}\text{C}$  or higher, but only for the range from room temperature to  $1,200^{\circ}\text{C}$ ; and (c) 5-, 6-, 8-, and 15-percent additions of  $\text{CaO}$  and heating at  $1,550^{\circ}\text{C}$  or higher, but additions of more than 6 percent caused the specimens to be very porous and proportionately weak. In all cases, however, the expansion during heating and contraction during cooling was relatively high. The coefficients of linear thermal expansion of the specimens that were all, or nearly all, cubic ranged from  $8.8$  to  $11.8 \times 10^{-6}$ . Also, zirconia has a low thermal conductivity relative to such materials of high thermal expansion as alumina, magnesia, and beryllia (unpublished data). Consequently, a high resistance to thermal shock cannot be expected of the stabilized product, even though it is not subject to the structural disintegration characteristic of the commercially pure material. 24 p. 10c.

RP1663. Acetyl derivatives of certain heptoses, of gulose, and of lactulose.

Harriet L. Frush and Horace S. Isbell

In the course of an investigation of the stereomeric factors that influence the course of replacement reactions, several new acetyl derivatives of the sugars were prepared. Inasmuch as the sugar acetates are of importance for analytical purposes, for the synthesis of other substances, and for the elucidation of structure, the new compounds are reported, even though the study of the reaction mechanisms has been temporarily discontinued. The preparation and properties are given for several new acetates of the heptoses, and for acetates of D-gulose, D-glucoseptulose, and lactulose.

The following new compounds are reported: Hexaacetyl-D-glycero- $\beta$ -D-ido-aldoheptose, melting point  $136^{\circ}\text{C}$ ,  $[\alpha]_D^{20}$ ,  $-9.1^{\circ}$ ; pentaacetyl-D-glycero-a-D-ido-aldoheptosyl bromide, melting point  $114^{\circ}\text{C}$ ,  $[\alpha]_D^{20}$ ,  $+143^{\circ}$ ; methyl pentaacetyl-D-glycero- $\beta$ -D-ido-aldoheptoside, melting point  $136^{\circ}$  to  $137^{\circ}\text{C}$ ,  $[\alpha]_D^{20}$ ,  $-31.3^{\circ}$ ; hexaacetyl-D-glycero-a-D-talo-aldoheptose, melting point  $137^{\circ}\text{C}$ ,  $[\alpha]_D^{20}$ ,  $+88.8^{\circ}$ ; hexaacetyl-D-glycero-L-galacto-aldoheptoses (crystalline mixture); pentaacetyl-D-gulose, melting point  $113^{\circ}\text{C}$ ,  $[\alpha]_D^{20}$ ,  $+86.2^{\circ}$  (needle form), and melting point  $105^{\circ}$  to  $106^{\circ}\text{C}$ ,  $[\alpha]_D^{20}$ ,  $+86.2^{\circ}$  (prismatic form); pentaacetyl-D-glucoseptulose, melting point  $114^{\circ}$  to  $115^{\circ}\text{C}$ ,  $[\alpha]_D^{20}$ ,  $+45.9^{\circ}$ ; octaacetylactulose, melting point  $138^{\circ}\text{C}$ ,  $[\alpha]_D^{20}$ ,  $-6.6^{\circ}$ . 14 p. 5c.

RP1664. Mass spectrometric analyses of hydrocarbon and gas mixtures.

A. Keith Brewer and Vernon H. Dibeler

The basic principles underlying mass spectrometric analysis of hydrocarbon and gas mixtures are outlined. The method of calculating the composition from the mass-abundance records is described. Analyses of a number of hydrocarbon and other gas mixtures are shown. Whenever possible comparisons with different methods of analyses are given. The reproducibility and the accuracy obtainable in mass spectrometric analyses are described. 16 p. 10c.

RP1665. Heats of combustion and isomerization of the eight  $C_9H_{12}$  alkylbenzenes.

Walter H. Johnson, Edward J. Prosen and Frederick D. Rossini

The heats of isomerization of the eight  $C_9H_{12}$  alkylbenzenes were determined by measurement of the ratios of the heats of combustion in the liquid state of purified samples of these compounds by the procedure previously described for the hexanes, heptanes, and octanes. The data yield the following values for the heat of isomerization in the liquid state at 25°C,  $\Delta H^\circ$ , of *n*-propylbenzene into each of the  $C_9H_{12}$  alkylbenzenes, in kilocalories per mole: *n*-propylbenzene, 0.00; isopropylbenzene,  $-0.67 \pm 0.16$ ; 1-methyl-2-ethylbenzene,  $-1.93 \pm 0.16$ ; 1-methyl-3-ethylbenzene,  $-2.48 \pm 0.19$ ; 1-methyl-4-ethylbenzene,  $-2.74 \pm 0.26$ ; 1,2,3-trimethylbenzene,  $-4.83 \pm 0.22$ ; 1,2,4-trimethylbenzene,  $-5.61 \pm 0.16$ ; 1,3,5-trimethylbenzene,  $-6.00 \pm 0.26$ . These data were combined with the value previously reported for the heat of combustion of *n*-propylbenzene to obtain values for the heats of combustion of each of the  $C_9H_{12}$  alkylbenzenes in the liquid state at 25°C. 6 p. 5c.

RP1666. Thin-walled aluminum beta-ray tube counters.

Burrell W. Brown and L. F. Curtiss

A description is given of aluminum-tube Geiger-Muller counters having a wall thickness of 0.004 inch and constructed from commercially available tooth-paste tubes. These tubes as furnished are in the hard temper and have uniform wall thickness, which enable them to stand complete evacuation without a tendency to collapse. By copperplating the aluminum it is possible to soft-solder fittings to the tube to construct a counter that can be permanently sealed after filling and that will maintain its characteristics over a long period. The procedure reduces the cost of making this type of counter, as the aluminum tubes are inexpensive, and very simple operations are required in the construction of the counters. 4 p. 5c.

RP1667. Method of lagrangian curvilinear interpolation.....William J. Taylor

This report describes a simplified method of computing Lagrangian coefficients for curvilinear interpolation, which may be used when tables of Lagrangian coefficients are not available or when tables are available but the coefficients are not tabulated for the exact fraction of the interval to which the interpolation is to be made. 6 p. 5c.

RP1668. An apparatus for photographing interference phenomena. James B. Saunders

A photographic instrument is described that was designed for recording the changes produced in the order of interference fringes over long periods and for recording large changes in the order of interference. When this instrument is used with interferometric systems for studying the changes caused in transparent solids by heating, it can be made to yield a continuous record of the simultaneous changes in temperature, time, index, strain, and density. For example, to record those changes that are caused by the annealing of an optical glass at an annealing temperature near the lower part of its annealing range requires several weeks of continuous recording. The total amount of 35-millimeter film needed by the instrument for such a record (covering, say 3 months) does not necessarily exceed 10 feet. To record the expansion of a material that is being heated from room temperature to 500°C, at a rate of 3 degrees centigrade per minute, requires approximately 1 foot of 35-millimeter film. Thus, even very long tests require such a small amount of film that the operator is able to process it in any small dark room. The fringes are photographed at their natural size, and the fringe shifts can be determined from the photographic record without the use of enlarging or projection equipment. 30 p. 10c.

RP1669. Lapped bar splices in concrete beams.

Ralph W. Kluge and Edward C. Tuma

An investigation was conducted to determine the general behavior and strength of lapped bar splices that varied in length and method of lapping. The bond strength developed in the splice and the slip of bar were determined for two types and two sizes of reinforcement. The resulting data clearly illustrated the manner in which the stress was transferred from one lapped bar to the other; the relative merits of the two



types of bars, as well as the effectiveness of the two methods of lapping, are also shown. 32 p. 10c.

RP1670. Vapor pressures and boiling points of some paraffin, alkylcyclopentane, alkylcyclohexane, and alkylbenzene hydrocarbons.  
Charles B. Willingham, William J. Taylor, Joan M. Pignocco, and Frederick D. Rossini

Measurements of vapor pressures and boiling points, over the range 47 to 780 millimeters of mercury and above about 12°C, were made on 52 purified hydrocarbons. The apparatus consisted of an electrically heated boiler, a vapor space with a vertical reentrant tube containing a platinum thermometer having a resistance of 25 ohms, and a condenser. Measurements of the temperature of the liquid-vapor equilibrium were made at 20 fixed pressures maintained automatically. The values of the fixed pressures were determined by calibration of the apparatus with water by using the vapor pressure-temperature tables prepared at the National Bureau of Standards.

The experimental data on the hydrocarbons were correlated, the method of least squares being used, with the three-constant Antoine equation for vapor pressures,  $\log P = A - B/(C + t)$  or  $t = B/(A - \log P) - C$ . Experimental data together with the values of the three constants of the Antoine equation, applicable over the range of measurement, are reported for 30 paraffin, 4 alkylcyclopentane, 10 alkylcyclohexane, and 8 alkylbenzene hydrocarbons. 26 p. 10c.

RP1671. Color standard for ruby mica.....Deane B. Judd

At the request of the Metals Reserve Company and the War Production Board, a study has been made of the color classification of mica used by the mica-consuming industry. This classification has been found to be consistent and can be reproduced from the chromaticity of the mica specimen and its daylight transmission considered in relation to thickness. A method of defining ruby mica in these terms is described, and as it does not depend upon the physical integrity of any material color standard, this definition constitutes a fundamental color standard for ruby mica. This standard is particularly for application to micas close to the border line between ruby and nonruby. 12 p. 5c.

RP1672. Compression of sole leather.....Charles E. Weir

Specimens of sole leather were subjected to indentation tests and compressive tests. Comparisons between compression data and the indentation numbers of the original dry leather show that compression may be used as a measure of indentation. Compression of dry leather gives results showing better correlation between the methods and eliminates distortions occurring when moist leather is compressed. Compression data show satisfactory reproducibility. Compression for a three-minute period is adequate for test purposes, all changes being completed in this interval with the exception of a very minute compression proceeding at a slow rate. Compensation for variations in thickness of specimens may be effected by expressing the results in terms of percentage compression. Area and shape of specimens do not affect the compression appreciably. Compression-decompression curves show large hysteresis loops. The effect of tannery rolling in compressing leather is estimated to be equivalent to that produced by pressures of from 2,000 to 3,000 lb/in<sup>2</sup>. Based upon the data obtained in the compressive tests, the lower limit of the coefficient of compressibility of leather is estimated to be  $33 \times 10^{-6}$  bar<sup>-1</sup>. 16 p. 5c.

RP1673. Knock ratings of gasoline substitutes.....Afton D. Puckett

Knock ratings of gaseous paraffins and olefins through C<sub>4</sub>, and of carbon monoxide, were determined by current motor and aviation test methods. Auxiliary apparatus and modifications of test engines necessary to rate gases are described.

Antiknock qualities of ethyl and normal butyl alcohol, and acetone, both alone and in blends, were determined by current motor-fuel rating procedures. Blending characteristics of these materials with straight run gasolines and naphthas were investigated.

Diethyl ether in ethyl alcohol blends showed a high positive sensitivity (Coordinating Fuel Research Committee (CFR) research minus American Society for Testing Materials (ASTM) motor octane number) for ether concentrations below 48 percent and a high negative sensitivity above that figure. The tests indicated that blends containing up to 45 percent of ether should give relatively knock-free performance under conditions of steady operation. 12 p. 5c.

RP1674. Hysteresis in the physical adsorption of nitrogen on bone char and other adsorbents.....Leland F. Gleysteen and Victor R. Deitz

An investigation has been made of some characteristics of hysteresis in the physical

adsorption of nitrogen on bone char, activated carbon, silica gel, and coconut-shell charcoal at 77.4°K. It was found that hysteresis became less pronounced in the order given, occurring only slightly in coconut-shell charcoal and only from high relative pressures in the pressure range in which the Langmuir equation was not obeyed. It was shown that it was highly probable that a true steady state was attained in the pressure determinations and that the time dependency of adsorption and desorption are compatible with the requirements of diffusion processes. In this paper the theories of hysteresis are reviewed on the basis of capillary condensation, and an alternative interpretation is suggested in terms of the theory of multimolecular adsorption. 24 p. 10c.

RP1675. Some physical properties of mica. . . . . Peter Hidnert and George Dickson

This paper gives data on the linear thermal expansion, changes in structure, power factors, and effects of heat treatments on the thickness, opacity, and color of micas (muscovite, phlogopite, biotite, ripidolite, and zinnwaldite) from different domestic and foreign sources. Tremendous linear thermal expansion was noted for some samples of phlogopite and biotite micas in a direction perpendicular to the cleavage plane. The transitions shown in the expansion curves of these samples at elevated temperatures appear to be related to the structural changes indicated in the X-ray diffraction patterns. Heat treatment of two phlogopite micas and two muscovite micas to 600°C, with or without a load, caused considerable increases in the power factors of the former and only slight changes in the latter. Nearly all the muscovite samples showed the greatest increases in thickness (up to 155 percent) after heat treatment at 800°C. The large increases in thickness of nearly all the muscovite samples accompanied changes from clear or translucent to opaque, or from polychrome to metallic color. None of the species of mica can be considered as a substance or material of fixed and reproducible properties. The physical properties of mica depend largely upon the chemical composition, the nature of the crystals, their magnitude and orientation, the presence of impurities, the way in which these enter the structure, the heat treatment, etc. Some of the phlogopite and biotite micas that possess tremendously high thermal expansion in a direction perpendicular to the cleavage plane may be used for high-expanding elements in temperature-responsive devices but may be unsatisfactory for use in devices in which large changes in dimensions with changes in temperature are not desirable. 46 p. 10c.

RP1676. Determination of the purity of hydrocarbons by measurement of freezing points.

Augustus R. Glasgow, Jr., Anton J. Streiff, and Frederick D. Rossini

An improved and simplified procedure is described for determining the freezing points of hydrocarbons from time-temperature freezing and melting curves, and for calculating the purity when the freezing point for zero impurity is (a) known and (b) not previously known. A procedure for determining the cryoscopic constant is also described. 20 p.

RP1677. Effect of pressure on the melting of crystalline rubber.

Lawrence A. Wood, Norman Bekkedahl, and Ralph E. Gibson

The effect of hydrostatic pressure on the melting of crystalline rubber has been the subject of a brief investigation extending to pressures above 1,000 atmospheres. With a particular sample of stark rubber, it was found possible to raise the temperature of melting, as determined by the disappearance of birefringence, from about 36° to 70°C by the application of a pressure of 1,170 bars ( $1,170 \times 10^6$  dynes/cm<sup>2</sup>). The results, including observations at intermediate pressures, can be represented adequately by the equation  $\log_{10}(p + 1,300) = 5.9428 - (875/T)$ . 6 p. 5c.

RP1678. Second dissociation constant of *o*-phthalic acid and related pH values of phthalate buffers from 0° to 60°C. . . . . Walter J. Hamer and S. F. Acree

Measurements were made of the potential difference between hydrogen electrodes and silver-silver-chloride electrodes in aqueous solutions of 72 different phthalate-chloride mixtures at 13 temperatures from 0° to 60°C. By described experimental and mathematical procedures, the second dissociation constant of *o*-phthalic acid and related thermodynamic quantities were evaluated, and pH values were assigned to 217 solutions, including some containing no potassium chloride. The addition of the chloride lowers the pH of the solutions principally because of an increase in the ionic strength.

The second dissociation constant may be computed at each temperature by the equation

$$\log K_2 = -2175.83/T + 9.55095 - 0.025694T,$$

where  $T = t^\circ\text{C} + 273.16$ .



The pH values of the solutions may be computed for ratios of dipotassium phthalate to acid potassium phthalate from 1 to 2, and for ionic strengths,  $\mu$ , from 0. to 0.5, by the equation

$$\text{pH} = -\log K_2 + \log \frac{\text{dipotassium phthalate}}{\text{acid potassium phthalate}} - 3A \sqrt{\mu}/(1 + 3.76B \sqrt{\mu}) + \beta\mu,$$

in which  $A$  and  $B$  are constants dependent upon the temperature, and  $\beta$  is a constant dependent upon the temperature, salt concentration, and buffer ratio.

The addition of potassium chloride lowers the pH of the solutions in accordance with the equation

$$\text{pH} = (\text{pH})_0 + \alpha_1 m \text{KCl} + \alpha_2 m^2 \text{KCl} + \alpha_3 m^3 \text{KCl},$$

where  $(\text{pH})_0$  is the value at any temperature for a solution containing no potassium chloride and  $\alpha_1$ ,  $\alpha_2$ , and  $\alpha_3$  are constants.

These solutions with or without potassium chloride are useful as pH standards from 4.87 to 5.72 and vary only slightly with changes in temperature. They have good buffer capacity and may be readily prepared from pure materials. The NBS Standard Samples 84a and 84b of acid potassium phthalate or Standard Samples of comparable purity are recommended for preparation of the solutions, together with carbonate-free potassium hydroxide of high grade and distilled water of pH 6.7 to 7.3. 36 p. 10c.

RP1679. Impact strength of nylon and of sisal ropes.

Sanford B. Newman and Helen G. Wheeler

Static and impact tests were made on spliced specimens of  $\frac{1}{8}$ -inch-diameter three-strand nylon rope and  $\frac{1}{8}$ -inch-diameter, four-strand, sisal rope.

The stretch of the ropes under impact and static loading up to failure was measured, and from these data energy-stretch behavior was determined.

It was found that the energy required to cause failure under impact loading was greater than the energy required to cause failure under static loading. The stretch of the rope at failure was practically the same under impact and static loading.

The results of these tests indicate that energy values computed from static tests of these ropes give a safe estimate of the performance of the rope under impact loading. 15 p. 10c.

RP1680. Oxidation of galacturonic acid and of 5-keto-gluconic acid in alkaline solution.

Horace S. Isbell and Nancy B. Holt

In the present investigation determinations were made of the quantities of oxalate, tartrate, and trihydroxyglutarate formed by the oxidation of galacturonic acid and of 5-keto-gluconic acid in the presence of various bases and various concentrations of the base. Although preliminary measurements indicate that the proportions of the products can be altered by use of catalysts, this report is restricted to the results obtained without the addition of catalytic substances. Oxidation of sodium galacturonate with oxygen in 1-N sodium hydroxide solution gave oxalate, D-tartrate (levo), and D-arabo-trihydroxyglutarate in yields of 0.10, 0.10, and 0.45 mole, respectively, per mole of galacturonate. Oxidation of sodium 5-keto-gluconate under like conditions gave oxalate, L-tartrate (dextro), and xylarabo-trihydroxyglutarate in yields of 0.29, 0.10, and 0.45 mole, respectively, per mole of sodium 5-keto-gluconate. Directions are included for the preparation of potassium D-arabo-trihydroxyglutarate from galacturonic acid. 6 p. 5c.

RP1681. Utilization of nonpetroleum fuels in automotive engines.

Jesse T. Duck and Clarence S. Bruce

A number of substitute fuels and blends were tested to determine their relative efficiency in the operation of common types of engines. The tests showed that the maximum power developed with alcohol and with some of the other fuels was slightly greater than with gasoline. The specific fuel consumption with the various fuels was approximately in inverse proportion to the heat of combustion of the fuel used. Analysis showed that the mixture distribution was less uniform with the substitute fuels than with gasoline. Tests made with low-proof alcohols showed that an engine can be operated on blends as low as 70 proof, but it is ordinarily impractical to use a blend much below 190 proof because of the excessive volume required. 27 p. 10c.

RP1682. Heats, equilibrium constants, and free energies of formation of the acetylene hydrocarbons through the pentyne, to 1,500°K.

Donald D. Wagman, John E. Kilpatrick, Kenneth S. Pitzer, and Frederick D. Rossini

Values are presented for the following thermodynamic properties for acetylene, propyne (methylacetylene), 1-butyne (ethylacetylene), 2-butyne (dimethylacetylene), 1-pentyne (*n*-propylacetylene), 2-pentyne (methyl ethylacetylene), and 3-methyl-

1-butyne (isopropylacetylene), in the gaseous state, to 1,500°K: The heat-content function,  $(H^\circ - H^\circ_0)/T$ ; the free-energy function,  $(F^\circ - H^\circ_0)/T$ ; the entropy,  $S^\circ$ ; the heat content,  $H^\circ - H^\circ_0$ ; the heat capacity,  $C_p^\circ$ ; the heat of formation from the elements,  $\Delta H_f^\circ$ ; the free energy of formation from the elements,  $\Delta F_f^\circ$ ; and the logarithm of the equilibrium constant of formation from the elements,  $\log_{10} K_f$ .

Equilibrium constants and concentrations of components are given in tabular and graphical form for the isomerization of the two butynes and of the three pentynes as a function of temperature to 1,500°K. Equilibrium constants are also given in tabular and graphical form for the dehydrogenation of ethane to ethylene to acetylene, of propane to propylene to propyne, of *n*-butane to 1-butene to 1-butyne, and of *n*-pentane to 1-pentene to 1-pentyne. 30 p. 10c.

RP1683. Reaction of periodic acid on the difructose anhydrides.

Emma J. McDonald and Richard F. Jackson

Diheterolevulosan, difructose anhydrides I, III, and II react, respectively, with 4, 2, 1, and 1 moles of periodic acid per mole of sugar. These results are in keeping with the known structures of the first three sugars. It is suggested that difructose anhydride II is a 1,2'-2,4'-difructofuranose. 4 p. 5c.

RP1684. Thermodynamic properties of solid and liquid ethylbenzene from 0° to 300°K. .... Russell B. Scott and Ferdinand G. Brickwedde

The following properties of a sample of high purity ethylbenzene were measured: (1) Specific heat of solid and liquid from 15° to 300°K; (2) triple-point temperature ( $-95.005 \pm 0.010^\circ\text{C}$  for pure ethylbenzene); (3) heat of fusion ( $86.47 \text{ int. j g}^{-1}$ ); (4) heat of vaporization at 294°K ( $400.15 \text{ int. j g}^{-1}$ ); and (5) vapor pressure from 273° to 296°K. With these experimental data, the enthalpy and entropy of the solid and of the liquid in the range 0° to 300°K were calculated. 12 p. 5c.

RP1685. Assembly and calibration of a density balance for liquid hydrocarbons.

Alphonse F. Forziati, Beveridge J. Mair, and Frederick D. Rossini

The assembly and calibration are described of a density balance for rapidly measuring the densities of liquid hydrocarbons on samples as small as 9 milliliters in volume. The reproducibility of the measurements is  $\pm 0.00002$  to  $\pm 0.00003$  gram per milliliter and the over-all uncertainty is estimated to be about  $\pm 0.00005$  gram per milliliter. 7 p. 5c.

RP1686. Ultraviolet spectra and dissociation constants of *p*-hydroxybenzoic acid, methyl, ethyl, *n*-butyl, and benzyl *p*-hydroxybenzoate and potassium *p*-phenolsulfonate.

Elizabeth E. Sager, Marjorie R. Schooley, Alice S. Carr, and S. F. Acree

The apparent first and second dissociation constants of *p*-hydroxybenzoic acid, the constants for the phenol group of methyl, ethyl, *n*-butyl, and benzyl *p*-hydroxybenzoate, and potassium *p*-phenolsulfonate have been determined from ultraviolet spectral data. The compounds have wide absorption bands located in the region of 200 to 400  $\text{m}\mu$ , and the differences between the transmittancy curves for their ionic and molecular forms are great enough to permit the measurement of several intermediate steps in the transformation at various pH values. The buffers used to control the dissociation were acetates, phosphates, and borates, all of low ionic strengths. Esterification of the carboxyl group of *p*-hydroxybenzoic acid apparently increases the dissociation of the phenol, and  $\text{p}K$  decreases from 9.3 for the second dissociation of the acid to 8.3 for the esters. The thermodynamic dissociation constants are estimated. 18 p. 10c.

RP1687. First dissociation constant of *o*-phthalic acid and related pH values of phthalate buffers from 0° to 60°C.

Walter J. Hamer, Gladys D. Pinching, and S. F. Acree

Measurements were made at 5-degree intervals from 0° to 60°C of the potential difference between hydrogen electrodes and silver-silver-chloride electrodes in 45 aqueous solutions that contained various amounts of *o*-phthalic acid, acid potassium phthalate, and potassium chloride. The first dissociation constant of *o*-phthalic acid and related thermodynamic quantities were evaluated, and pH values were assigned to each of the 45 solutions.

The equation obtained for the first dissociation constant as a function of temperature is

$$\log K_1 = -561.57/T + 1.2843 - 0.0078833 T,$$

where  $T = t^\circ\text{C} + 273.16$ .

The pH values of the solutions range from 2.70 to 3.26 and vary only slightly with changes in temperature. The solutions have good buffer capacity and may



be readily prepared from pure materials. Each solution is suited for use as a pH standard.

The separation of the carboxyl groups in *o*-phthalic acid was found to be 1.66 Å by means of an equation relating this distance with the ratio of the two dissociation constants of *o*-phthalic acid. This value is higher than 1.53 Å obtained from X-ray measurements of the carbon-carbon distance in the diamond and 1.43 in the benzene molecule.

The problem of convergence or lack of convergence of apparent dissociation constants calculated by different methods to a single thermodynamic value in the limit of infinite dilution is discussed. 26 p. 10c.

Title page and contents for volume 35. 6 p. 5c.

RESEARCH PAPERS FROM JOURNAL OF RESEARCH OF THE NATIONAL BUREAU OF STANDARDS, VOLUME 36, JANUARY—JUNE 1946

RP1688. Specification of railroad signal colors and glasses.

Kasson S. Gibson, Geraldine Walker Haupt, and Harry J. Keegan

This paper is a continuation of Bureau Research Paper RP1209 and describes the cooperative work done by the Association of American Railroads Signal Section, Corning Glass Works, and the National Bureau of Standards leading to the formulation of the AAR Signal Section specifications for signal colors and glasses.

The previous paper defined the luminous transmission scale used by the signal engineers and glass manufacturers. The present paper describes the glasses selected by these engineers to define the limits of acceptable chromaticities afforded by these glasses when combined with kerosine or electric illuminant. The spectral transmissions of the glasses are given, together with the luminous transmissions and chromaticities for the specified illuminants.

The photometric and colorimetric parts of the AAR Signal Section three-part specifications are illustrated and the reasons given for the choice of tolerances both on the acceptable signal colors and on the glasses certified by the National Bureau of Standards as duplicates of the standard limit glasses.

Various other data of interest are given, including the expression of the permissible chromaticities of signal colors in a uniform-chromaticity-scale coordinate system. 30 p. 10c.

RP1689. Attack on refractory clay pots by optical glasses.

Willard H. Parsons and Herbert Insley

Examinations were made of the walls and bottoms of approximately 200 refractory clay pots of lined and unlined types to determine the extent of penetration of optical glasses into refractory material. Examinations made with a petrographic microscope of samples of unused pot bottom indicated the structure of the heat-treated refractory. Similar examinations of selected samples from the bottoms of 62 used pots revealed the manner of attack by corrosive glasses and identified the crystalline and glassy reaction products formed. These reaction products were found at the interface between refractory and glass and within pot bottoms penetrated by glass. The pots were used in the manufacture of barium crown, barium flint, light crown, borosilicate crown, and several different flint optical glasses. 15 p. 10c.

RP1690. pH standards at various temperatures: Aqueous solutions of acid potassium phthalate....Walter J. Hamer, Gladys D. Pinching, and S. F. Acree

pH values of aqueous solutions of acid potassium phthalate, National Bureau of Standards Standard Sample 84a, are given for concentrations from 0.001 to 0.2 *m* and for temperatures between 0° and 60°C. They were calculated from the values of the two dissociation constants of *o*-phthalic acid and the activity coefficients of the acid phthalate and phthalate ions. The pH values range from 3.88 to 4.42. They may be computed for any temperature from 0° to 60°C, inclusive, by the equation

$$\text{pH} = A^*/T + B + CT$$

or by the equation

$$\text{pH} = \text{pH}_{15} + k(t - 15)^2$$

where  $A^*$ ,  $B$ ,  $C$ , and  $k$  are constants whose numerical values are dependent upon the molality of the solutions,  $\text{pH}_{15}$  is the pH value at 15°C, and  $T = t^\circ\text{C} + 273.16$ .

A 0.05-*m* solution of acid potassium phthalate, the one used most extensively in the calibration of pH assemblies, has a pH value of 4.005 at 25°C. Its pH value at any temperature from 0° to 60°C, inclusive, may be computed by the equation

$$\text{pH} = 1336.08/T - 5.2678 + 0.016069T,$$

or by the equation

$$\text{pH} = 4.000 + 0.0000479(t - 15)^2.$$

The pH values of a 0.05-*m* solution of acid potassium phthalate prepared with Stand-

ard Samples 84a and 84b were found to agree within 0.001 pH unit at the various temperatures.

Directions are included for preparations of the solutions on a molal and a molar scale of concentration. A critique of the method of evaluating the pH values and comparisons with older values reported for 0.05-*M* and 0.2-*M* solutions are given. 16 p. 5c.

RP1691. Extraction of alumina from clays and high-silica bauxites.

E. P. Flint, W. F. Clarke, E. S. Newman, Leo Shartsis, D. L. Bishop, and Lansing S. Wells

Two processes for extracting alumina from low-grade ores are described, one applicable to both clays and high-silica bauxites, and the other only to bauxites. In the former process, a line-containing sinter is prepared and annealed by cooling it slowly through the range of 1,300° to 1,200°C. The annealed sinter dusts to a powder which requires no grinding. This material is extracted with a solution containing about 200 g of  $\text{Na}_2\text{CO}_3$  and 150 g of  $\text{NaCl}$ /liter, and an extract is obtained in which the concentration of  $\text{Al}_2\text{O}_3$  is 70 to 80 g/liter and that of  $\text{SiO}_2$ , 1 to 2 g/liter. By boiling the extract with a seed charge of synthetic sodalite,  $3\text{Na}_2\text{O} \cdot 3\text{Al}_2\text{O}_3 \cdot 6\text{SiO}_2 \cdot 2\text{NaCl}$ , its silica content is reduced to 0.1 percent of the alumina content or less. Alumina, suitable for the manufacture of aluminum by electrolytic reduction, is precipitated by passing carbon dioxide into the desilicated solution. About 95 percent of the alumina in the clay is recovered by this method.

The other process developed in this investigation involves the extraction of alumina from high-silica bauxites with sodium hydroxide-sodium chloride solution and recovery of soda and alumina from the residues by a modified soda-lime-sinter method. Recoveries in excess of 90 percent of the alumina in high-silica bauxites are obtained.

In cyclical operation of each process, the spent solution from the alumina-precipitation step is used in the treatment of a fresh batch of material.

When the bauxites are extracted with solutions containing mixtures of sodium hydroxide and sodium carbonate, sodium sulfate, sodium bromide, or sodium nitrate, the quantities of silica present in the extracts are lower, the higher the concentration of the salt. This is caused by the formation and increased stabilization of slightly soluble compounds related to sodalite. Comparisons of the X-ray diffraction patterns of various sodalite type compounds are presented. By the extraction of bauxite with sodium hydroxide solution, in the absence of added salts, a relatively soluble hydrated nephelite,  $\text{Na}_2\text{O} \cdot \text{Al}_2\text{O}_3 \cdot 2\text{SiO}_2 \cdot 2\text{H}_2\text{O}$ , is formed, which has a crystal structure different from that of sodalite. 44 p. 10c.

RP1692. Stability of double-walled manganin resistors. . . . . James L. Thomas

The international ohm is now maintained at the National Bureau of Standards by means of double-walled manganin resistors. It is assumed that the average resistance of a group of 10 standards, selected from a group of 24 constructed in 1933, remains constant with time. No one of the 10 standards has changed in resistance with reference to their average by more than 1 part in a million in 12 years. 4 p. 5c.

RP1693. Heat capacity of a two-phase system, with applications to vapor corrections in calorimetry. . . . . Harold J. Hoge

A formula is derived that gives the heat capacity of a system composed of solid or liquid in equilibrium with saturated vapor in terms of the specific heat of the condensed phase and certain auxiliary data. This formula is valid throughout the entire range from 0 to 100 percent of vapor, and at the latter extreme reduces to a well-known relation between the specific heats of saturated liquid and saturated vapor.

The formula is applied to the calculation of vapor corrections in calorimetry. Its advantage lies in the fact that the correction is expressed as a single term that may be readily transformed with Clapeyron's equation, yielding two alternative correction formulas.

Vapor corrections to the heat capacity and to the heat of fusion are summarized and tabulated for four different experimental procedures in calorimetry. 8 p. 5c.

RP1694. A method for determining small amounts of gold, and its use in ascertaining the thickness of electrodeposited gold coatings. . . . W. Stanley Clabaugh

This paper presents a method for the determination of the thickness of gold electrodeplate, using a punch and die to obtain samples of known small area. Amounts of gold up to 10 micrograms (0.010 mg), corresponding to a thickness of 0.00050 mm (0.00002 in.) or less on 1 mm<sup>2</sup> (0.00155 in.<sup>2</sup>) of surface, are determined directly by means of the color produced with *o*-tolidine. Results are reported for thicknesses of gold plate on experimentally plated samples and on commercially plated products. 9 p. 5c.



RP1695. Purification and properties of 29 paraffin, 4 alkylcyclopentane, 10 alkylcyclohexane, and 8 alkylbenzene hydrocarbons.

Alphonse F. Forziati, Augustus R. Glasgow, Jr., Charles B. Willingham, and Frederick D. Rossini

This report gives the results of the purification and measurements of refractive index ( $n_D$  at 20° and 25°C), density (at 20° and 25°C), boiling point and pressure coefficient of the boiling point (at 1 atm) and, except for four of the compounds, the freezing point, together with the calculated amount of impurity, of samples of 51 hydrocarbons, including 29 paraffins, 4 alkylcyclopentanes, 10 alkylcyclohexanes, and 8 alkylbenzenes. 8 p. 5c.

RP1696. Effect of some added materials on dicalcium silicate.

Edwin S. Newman and Lansing S. Wells

Studies of binary systems are helpful in the investigation of polycrystalline systems forming industrial products, such as portland cement, dolomite refractories, or blast-furnace slags. Details are given of the application of differential heating and cooling curves to the determination of the temperature of the  $\alpha \rightleftharpoons \beta$  inversion of  $2\text{CaO} \cdot \text{SiO}_2$  in binary mixtures with  $\text{CaO}$ ,  $\text{SiO}_2$ ,  $\text{Al}_2\text{O}_3$ ,  $\text{MgO}$ ,  $\text{Fe}_2\text{O}_3$ ,  $\text{CaF}_2$ ,  $\text{TiO}_2$ ,  $\text{BaO}$ ,  $\text{Cr}_2\text{O}_3$ ,  $\text{B}_2\text{O}_3$ ,  $\text{Mn}_2\text{O}_3$ ,  $\text{V}_2\text{O}_5$ ,  $\text{P}_2\text{O}_5$ ,  $\text{Na}_2\text{O}$ , and  $\text{K}_2\text{O}$ . These added materials, excepting  $\text{CaO}$ , lowered the temperature of the  $\alpha \rightleftharpoons \beta$  inversion and estimates of the limits of solid solution in  $\alpha\text{-}2\text{CaO} \cdot \text{SiO}_2$  are given. X-ray patterns of  $\beta\text{-}2\text{CaO} \cdot \text{SiO}_2$  containing  $\text{BaO}$ ,  $\text{P}_2\text{O}_5$ ,  $\text{Na}_2\text{O}$ , or  $\text{K}_2\text{O}$  indicated the existence of solid solutions of the substitution type. Observations were made of the effectiveness of the added materials in preventing dusting, which results from the  $\beta \rightarrow \gamma$  inversion of  $2\text{CaO} \cdot \text{SiO}_2$ . It was found that  $\text{Mn}_2\text{O}_3$  should be added to the list of known chemical inhibitors of dusting. 22 p. 10c.

RP1697. Reproducibility of the lead electrode and the electromotive force of the lead stick-lead amalgam cell at 0° to 60°C.

Roger G. Bates, Murray Edelstein, and S. F. Acree

The potentials of four types of solid lead electrodes with respect to saturated lead amalgam were obtained. Although lead anneals spontaneously, the surface condition has a profound effect upon the electromotive force. Untreated lead sticks were, in general, positive to lead the surface of which had been rendered strain-free. When etched in a mixture of nitric acid and lead nitrate, these lead sticks soon reached the same potential. Removal of air from the solutions improved the agreement among the electrodes.

Twelve sticks cast from National Bureau of Standards Standard Sample 49b and twelve cast from "spectroscopically pure" lead were etched and used to determine the difference of potential between stick lead and 8-percent lead amalgam at intervals of 5 degrees from 0° to 60°C. The results are given by the equation

$$E = 0.005347 + 0.0000201t,$$

where  $E$  is the electromotive force in international volts and  $t$  is in degrees centigrade. Thermodynamic constants were computed from the temperature coefficient of electromotive force. No difference was found between the two kinds of lead. 12 p. 5c.

RP1698. Engine tests with producer gas. Frederic A. Middleton and Clarence S. Bruce

Bench tests with a four-cylinder stationary engine were made with gasoline and producer gas from charcoal as the fuels. A comparison of their performance revealed that maximum power from producer gas from charcoal is about 55 percent of gasoline power, and that about 11.4 pounds of charcoal is equivalent to 1 gallon of gasoline. When operating an engine on producer gas the spark should be advanced beyond the setting for maximum power with gasoline. 14 p. 5c.

RP1699. Phase equilibrium relations in a portion of the system  $\text{Na}_2\text{O}-\text{CaO}-\text{Al}_2\text{O}_3-\text{SiO}_2$ .....Kenneth T. Greene and R. H. Bogue

A study of a portion of the system  $\text{Na}_2\text{O}-\text{CaO}-\text{Al}_2\text{O}_3-\text{SiO}_2$  has been made as a step in the solution of the problem of the state of combination of  $\text{Na}_2\text{O}$  in portland cement clinker. Quenching data are given for compositions in the tetrahedron formed by  $2\text{CaO} \cdot \text{SiO}_2$ ,  $\text{CaO}$ ,  $\text{Na}_2\text{O} \cdot \text{Al}_2\text{O}_3$ , and  $\text{Al}_2\text{O}_3$ , and phase diagrams are shown for three composition planes through the space model. Five invariant points were located approximately, at one of which  $2\text{CaO} \cdot \text{SiO}_2$ ,  $3\text{CaO} \cdot \text{SiO}_2$ ,  $3\text{CaO} \cdot \text{Al}_2\text{O}_3$ , and  $\text{Na}_2\text{O} \cdot 3\text{CaO} \cdot 3\text{Al}_2\text{O}_3$  are in equilibrium with liquid. This point, which is not a eutectic, occurs at  $1,440^\circ \pm 10^\circ\text{C}$  and has a composition of 3.5 percent  $\text{Na}_2\text{O}$ , 55.2 percent  $\text{CaO}$ , 31.0 percent  $\text{Al}_2\text{O}_3$ , and 10.3 percent  $\text{SiO}_2$ . Evidence was obtained of the formation, under favorable conditions, of a solid solution between  $3\text{CaO} \cdot \text{Al}_2\text{O}_3$  and  $\text{Na}_2\text{O} \cdot 3\text{CaO} \cdot 3\text{Al}_2\text{O}_3$  at temperatures below that of liquid formation. Present information indicates that  $\text{Na}_2\text{O}$  may be present in

clinker in several possible forms: (1) in glass, (2) as  $\text{Na}_2\text{O} \cdot 0.8\text{CaO} \cdot 3\text{Al}_2\text{O}_3$  or a solid solution of this compound and  $3\text{CaO} \cdot \text{Al}_2\text{O}_3$ , (3) in solid solution in  $2\text{CaO} \cdot \text{SiO}_2$ , (4) as inclusions of a soda-bearing phase in  $\beta$ - $2\text{CaO} \cdot \text{SiO}_2$  produced by ex-solution on inversion from  $\alpha$ - $2\text{CaO} \cdot \text{SiO}_2$ . 23 p. 10c.

RP1700. Spectrophotometric and colorimetric determination of the colors of the TCCA standard color cards.

Genevieve Reimann, Deane B. Judd, and Harry J. Keegan

The color cards of the Textile Color Card Association of the United States are widely used in the textile and allied industries and by many procuring agencies of the Federal Government. The Textile Color Card Association issues both seasonal and standard color cards. The seasonal cards provide a color-forecasting service to textile manufacturers and promote color coordination among the trades; the standard cards present colors for which there is a popular and continuing demand. Most important of the color cards is the Standard Color Card of America, the current ninth edition containing 216 colors. Preeminent among the many special sets of color cards issued by the Association for use of the Federal Government is the United States Army Color Card showing 22 official colors for the army and services. The specification of the colors of the Ninth Edition Standard Color Card and the United States Army Color Card has been undertaken for the purpose of correlating these textile standards with American War Standard Z44-1942 for the specification and description of color. The 238 samples comprising these color cards have been examined by basic spectrophotometric and colorimetric procedures. From this study there have been found daylight reflectance,  $Y$ , chromaticity coordinates ( $x, y$ ), Munsell rennotations, and ISCC-NBS color designations for these samples, as recommended by American War Standard Z44-1942. As more than half of these textile standards are fluorescent, and as existing spectrophotometers are not suited to the evaluation of such samples, considerable reliance has been placed on quantitative colorimetric and photometric comparisons with the Munsell color standards, both by means of a chromaticity-difference colorimeter and by the Martens photometer.

As a closing check, Munsell book notations of these textile standards have been obtained by a direct visual comparison with the color scales of the Munsell Book of Color. 39 p. 15c.

RP1701. Wearing quality of experimental currency-type papers.

Frederick T. Carson and Merle B. Shaw

Fourteen groups of high-grade papers, differing in fiber composition, were made in the Bureau's experimental paper mill. Papers within the groups differed in the beating treatment of the pulp, in the surface-sizing treatment, and in the use or omission of melamine resin. Of the several kinds of fibers studied, carao mixed with cotton appears to approach most nearly the desirable characteristics associated with linen-content currency paper. The high-quality wood fibers available do not appear suitable for use in currency paper. Melamine resin in currency-type paper improves folding endurance, tensile and bursting strength, strength after crumpling, stretch, resistance to abrasion, and closure of the sheet. It greatly increases the strength of the paper when wet. However, it makes the dry paper somewhat easier to tear. 20 p. 10c.

RP1702. Heats of formation, hydrogenation, and combustion of the monoolefin hydrocarbons through the hexenes, and of the higher 1-alkenes, in the gaseous state at 25°C. . . . . Edward J. Prosen and Frederick D. Rossini

For ethylene, propylene, the four butenes, the six pentenes, and the 17 hexenes, and all the higher 1-alkene hydrocarbons, in the gaseous state at 25°C, values are given for the heats of formation (from the elements solid carbon (graphite) and gaseous hydrogen), the heats of hydrogenation in the gaseous state, and the heats of combustion (in oxygen to form gaseous carbon dioxide and liquid water). The values for 2 of the pentenes, 14 of the 17 hexenes, and all the higher 1-alkene hydrocarbons, were calculated by a method involving correlation of the heat of hydrogenation with structure and the use of constants evaluated from the available experimental data on 4 butenes, 4 pentenes, 3 hexenes, and 1 heptene. 7 p. 5c.

RP1703. Studies of binary and ternary combinations of magnesia, calcia, baria, beryllia, alumina, thoria and zirconia in relation to their use as porcelains.

R. F. Geller, P. J. Yavorsky, B. L. Steierman, and A. S. Creamer

Specimens formed by pressing were heated and tested for absorption and shrinkage to determine the vitrification range. These pressed specimens represented the various oxides in simple binary and ternary combinations and also with minor additions of auxiliary oxides. Vitrified pieces were tested for strength in compression, thermal conduction and expansion, electrical resistance, dielectric properties, water



solubility, and resistance to attack by PbO liquid and vapor. Several compositions of unusual and valuable properties were disclosed. Phase relations were approximated by fusion tests and petrographic examinations of nonquenched samples. 36 p. 15c.

RP1704. Analysis of a standard sample of the carburetted water-gas type by laboratories cooperating with the American society for testing materials.

Martin Shepherd

This is a report of the analysis of a standard sample of carburetted water-gas by 24 laboratories in cooperation with Subcommittee VII of Committee D-3 of the American Society for Testing Materials. The data are presented in a series of frequency distribution plots, which show at a glance how the analyses compare with respect to each component of the gas mixture, as well as the calculated heating value and specific gravity. These plots form a clear picture of this type of gas analysis in this country. Although some very creditable work was reported, the need for some standardization is evident. 37 p. 15c.

RP1705. Spectrographic determination of boron in steel.

Charles H. Corliss and Bourdon F. Scribner

The spectrographic determination of small amounts of boron in thin steel rods and in massive pieces of steel was investigated by using several types of arc-like discharges. The sensitivity and accuracy in determining boron were found to be affected by variations in the rate of cooling of the electrodes. With  $\frac{3}{32}$ -inch-rod electrodes, the high-voltage alternating-current arc permits determinations down to 0.0006 percent of boron, with an average deviation of  $\pm 4$  percent. With more massive specimens the high-voltage alternating-current arc is insensitive, but an over-damped condenser discharge or similar source provides adequate sensitivity and precision. Determinations as low as 0.0001 percent of boron are made with a direct-current arc to which sodium is added to suppress an interfering Fe II line. In the course of the investigation, a series of six boron steels in two sizes,  $\frac{3}{32}$ - and  $\frac{1}{2}$ -inch rods, were issued as National Bureau of Standards Standard Samples covering the range 0.0006 to 0.019 percent of boron. 14 p. 5c.

RP1706. Hygroscopicity of optical glasses as an indicator of serviceability.

Donald Hubbard

Several modifications of a powder-hygroscopicity method have been tried as a rapid means of determining the serviceability of optical glasses, i. e., their ability to maintain a clear polished surface under normal conditions of service. The method has been applied to a wide variety of glasses, and it shows the typical optical glasses in common use to be much less hygroscopic than the average commercial sheet and container glasses. In fact, many of the optical glasses even compare favorably with the better chemical laboratory wares, such as Pyrex, Tamworth, and Kimble N-51-a. This grouping of these glasses of such very dissimilar chemical durabilities serves well to emphasize that the capacity of a glass to maintain a clear surface upon exposure to the atmosphere, and its chemical durability as conventionally determined are two inherently different properties. A comparison of the hygroscopicity values of the Corning 015 electrode glass with those of the optical and chemical ware glasses whose electrode capacity is very poor suggests strongly that the pH response of a glass is primarily a function of its hygroscopicity. Tests made on a limited number of glasses of the binary series  $\text{Na}_2\text{O-SiO}_2$ ,  $\text{K}_2\text{O-SiO}_2$ ,  $\text{Li}_2\text{O-SiO}_2$ , and  $\text{PbO-B}_2\text{O}_3$  appear to reflect some of the critical compositions of the respective phase equilibrium diagrams. 11 p. 5c.

RP1707. Solubility of cadmium sulfate in  $\text{H}_2\text{O-D}_2\text{O}$  mixtures.

Langhorne H. Brickwedde

The work reported here is a continuation of earlier studies on the effect of heavy water on the electromotive force of standard cells.

The solubility of cadmium sulfate was measured in heavy water and in normal water. This salt was found to be about 8 percent less soluble in heavy water than in normal water in the temperature range  $-1^\circ$  to  $+70^\circ\text{C}$ .

At  $43.6^\circ\text{C}$ ,  $\text{CdSO}_4 \cdot 8/3\text{H}_2\text{O}$ ,  $\text{CdSO}_4 \cdot \text{H}_2\text{O}$ , and saturated  $\text{H}_2\text{O}$  solution are in equilibrium.  $\text{CdSO}_4 \cdot 8/3\text{D}_2\text{O}$ ,  $\text{CdSO}_4 \cdot \text{D}_2\text{O}$ , and saturated  $\text{D}_2\text{O}$  solution are in equilibrium at  $45.4^\circ\text{C}$ . 7 p. 5c.

RP1708. A glossmeter for smoothness comparisons of machine-finished surfaces.

Richard S. Hunter

As shininess is one indication of surface smoothness, a photoelectric glossmeter was developed for possible use as a production-inspection device for evaluating the roughness of fairly coarse machine-finished surfaces. A near-grazing angle,  $75^\circ$  degrees, was chosen for the measurement of gloss. Therefore, specimens of the type having narrow ridges of metal between adjacent tool cuts are rated low in gloss, or rough.

Although the glossmeter essentially measures the fraction of the unshadowed surface that is nearly parallel to mean surface, the instrument resulting from the present development has proved to be a simple and useful device for making rapid comparisons of the roughness of surfaces machined with about the same feeds. 7 p. 5c.

RP1709. Absorption and scattering by sound-absorbent cylinders.

Richard K. Cook and Peter Chrzanowski

The absorption and scattering of a plane wave of sound by an infinitely long circular cylinder whose axis is perpendicular to the direction of propagation of the wave are calculated. The surface of the cylinder is assumed to have a known normal acoustic impedance. The calculations take account of diffraction effects. Absorption measurements were made on long cylinders placed in a reverberation room, where the incident wave directions are at all angles to the axes of the cylinders, and were compared with the calculated values. In order to make the comparison, the reverberation-room statistics appropriate for cylinders (which are different from the statistics for flat patches of absorbent material) are developed and applied. The theory predicts, and measurements confirm, that absorbent cylinders can have coefficients of absorption greater than unity. Fairly good agreement between the calculated and measured coefficients is found. The reverberation-room statistics appropriate for spherical absorbers are also developed, although no measurements were made on spheres. 18 p. 10c.

RP1710. Dynamic tensile tests of parachute webbing.

Ambrose H. Stang, Martin Greenspan, and Sanford B. Newman

Dynamic-load-stretch and stretch-energy data were obtained for two types of nylon and one type of cotton parachute webbing. These data were compared with similar data obtained from static tensile tests of the materials. The dynamic and static breaking strengths of the webbing were also obtained.

The nylon specimens showed a reduced strength, stretch, and capacity for energy absorption under dynamic loading as compared with static loading. The cotton specimens showed under dynamic loading about the same strength, reduced stretch, and increased energy absorption. The energy absorbed by the broken nylon specimens was more than three times that of the broken cotton specimens. 9 p. 5c.

RP1711. Note on the density and heat of combustion of benzoic acid... R. S. Jessup

The results of various determinations of the density of benzoic acid are summarized. The three most recent values are in reasonably good agreement with each other, but are higher by about 4.5 percent than the value most commonly referred to in the literature. The difference of 4.5 percent in density affects the reduction of weight in air to mass by an amount corresponding to 0.004 percent in mass, and in heat of combustion per gram mass. 3 p. 5c.

RP1712. An analysis of the effects of fuel distribution on engine performance.

Donald B. Brooks

From an empirical equation, based on single-cylinder-engine test data and relating engine power to fuel consumption, engine-performance curves are derived analytically for typical examples of poor mixture distribution. Investigation of the resulting information shows that the minimum specific fuel consumption is a satisfactory criterion of distribution quality. A method is developed for ascertaining the attainable improvement over a given distribution. 15 p. 5c.

RP1713. Effects of mildew on vegetable-tanned strap leather.

Joseph R. Kanagy, Arbelia M. Charles, Edward Abrams, and Rees F. Tener

Samples of vegetable-tanned strap leather were exposed to conditions favorable for mildew growth in a tropical room at Fort Belvoir, Va., and in soil burial beds and in a humidity cabinet at the National Bureau of Standards. Mildew under these conditions varied from moderate to very heavy growth.

Physical tests showed that the growth of mildew on leather increased its stiffness, caused a loss in tensile strength, decreased stretch at the breaking point, and weakened the grain surface. Chemical tests revealed a loss of grease, water solubles, glucose, tannins, and nontannins.

No appreciable deterioration of the hide substance was indicated by the tests. The change in physical properties appeared to be due to the mildew activity impairing principally the outer surface of the leather.

The molds in assimilating the grease bring about decomposition (decarboxylation) of the fatty acids. This is shown by a decrease in the saponification number.

Samples of leather containing a fungicidal oil having as active ingredients a mixture of paranitrophenol and pentachlorophenol in equal proportions and aged under



the same conditions as the untreated leathers showed no evidence of mildew after 12 weeks. 14 p. 5c.

RP1714. Heats of combustion and formation at 25°C of the alkylbenzenes through  $C_{10}H_{14}$ , and of the higher normal monoalkylbenzenes.

Edward J. Prosen, Walter H. Johnson, and Frederick D. Rossini

Values are given for the heats of combustion (in oxygen to form gaseous carbon dioxide and liquid water) and the heats of formation (from the elements, solid carbon (graphite) and gaseous hydrogen), at 25°C, for benzene, toluene, the four  $C_8H_{10}$ , the eight  $C_9H_{12}$ , and the 22  $C_{10}H_{14}$  alkylbenzenes, in both the liquid and gaseous states, and for the higher normal monoalkylbenzenes in the gaseous state. 7 p. 5c.

RP1715. Heats of combustion of four cyclopentane and five cyclohexane hydrocarbons... Walter H. Johnson, Edward J. Prosen, and Frederick D. Rossini

The heats of combustion of cyclopentane, methylcyclopentane, ethylcyclopentane, *n*-propylcyclopentane, cyclohexane, methylcyclohexane, ethylcyclohexane, *n*-propylcyclohexane, and *n*-butylcyclohexane were measured with a bomb calorimeter. The following values were obtained for —  $\Delta H_c^{\circ}_{298.16}$ , the heat of combustion at 25°C and constant pressure of the liquid hydrocarbon in gaseous oxygen to form gaseous carbon dioxide and liquid water, with all the reactants and products in their thermodynamic standard reference states, in international kilojoules per mole (with the corresponding value in terms of the conventional thermochemical calorie being given in parentheses):

Cyclopentane,  $3290.34 \pm 0.72$  (786.54  $\pm$  0.17)  
Methylcyclopentane,  $3937.07 \pm 0.75$  (941.14  $\pm$  0.18)  
Ethylcyclopentane,  $4591.17 \pm 0.94$  (1097.50  $\pm$  0.22)  
*n*-Propylcyclopentane,  $5244.75 \pm 1.18$  (1253.74  $\pm$  0.28)  
Cyclohexane,  $3919.26 \pm 0.70$  (936.88  $\pm$  0.17)  
Methylcyclohexane,  $4564.52 \pm 0.95$  (1091.13  $\pm$  0.23)  
Ethylcyclohexane,  $5221.71 \pm 1.46$  (1248.23  $\pm$  0.35)  
*n*-Propylcyclohexane,  $5874.79 \pm 1.15$  (1404.34  $\pm$  0.27)  
*n*-Butylcyclohexane,  $6529.21 \pm 1.22$  (1560.78  $\pm$  0.29).

5 p. 5c.

RP1716. Size grading of diamond powder.

B. L. Steierman, H. Insley, and W. H. Parsons

A study has been carried out on certain aspects of diamond-powder grading. Various liquids were tried as dispersing media, and of the 30 materials tested, gelatin solution was found to be the best. Several methods of separating the powder into size fractions were investigated and are discussed. The Cooke short-column elutriator was found satisfactory for determining the size of large quantities of powder with little manual attention. Results of size fractionation are shown by photomicrographs. 10 p. 5c.

RP1717. Precision of telescope pointing for outdoor targets.

Francis E. Washer and Helen Brubaker Williams

The probable error of a single pointing ( $PE_s$ ) is measured for a single telescope with a variety of targets. This investigation shows that, although some change in  $PE_s$  with distance does occur, the distribution of  $PE_s$  as a function of distance can usually be neglected and a value of 0.62 second assigned as a practical average. The values of  $PE_s$  for an indoor target usually show a small variation from one experienced observer to another, and from right to left eye of the same observer. There is also a measurable systematic difference in pointing between the right eye and the left eye of the same observer. In outdoor pointing, a long-period error or drift is usually superposed upon the short-period errors. 10 p. 5c.

RP1718. Crystallization of unvulcanized rubber at different temperatures.

Lawrence A. Wood and Norman Bekkedahl

The crystallization and melting of unvulcanized natural rubber in the unstretched state have been investigated at different temperatures. Change of volume has been used as a quantitative measure of the extent of crystallization, and mercury-filled dilatometers containing the rubber have been used for the volume measurements.

Crystallization was observed to occur at temperatures between — 50° and + 15°C and to be most rapid at about — 25°C. The final decrease of volume on crystallization was usually found to lie between 2.0 and 2.7 percent.

The melting of the crystalline rubber was found to occur over a range of temperature and to be strongly dependent on the temperature at which the crystals were formed. The temperature at which the beginning of melting occurs is from

4 to 7 degrees above the temperature of crystallization. The range of melting is about 35 degrees at the lowest temperatures and decreases to about 10 degrees at the highest. The same range of temperature of melting is obtained regardless of the extent of the crystallization. 22 p. 10c.

RP1719. Hygroscopicity and electrode function (pH response) of glasses as a measure of serviceability.....Donald Hubbard

The pH responses of electrodes prepared from glasses of widely different composition have been compared with the hygroscopicity of the glasses. The resulting data indicate that glasses of low hygroscopicity, such as the chemical glasswares and common types of optical glasses, give pH responses that fall appreciably below the theoretical predicted from the Nernst equation and are incapable of producing satisfactory electrodes. Further, electrodes blown from glasses of intermediate hygroscopicity, such as the common bottle and sheet glasses, give pH responses more nearly approximating the theoretical, whereas the Corning 015 glass, whose superior pH response places it in a class by itself, has a very high hygroscopicity. These results strongly support the belief that adequate hygroscopicity is one of the primary factors in determining the suitability of a glass for pH measurements. The data also suggest that the pH response might well be used as a rapid test for the serviceability of optical glasses, i. e., the ability to maintain a clear polished surface upon exposure to the atmosphere. For this purpose it is necessary to determine the pH response over a range in which the "chemical durability" of the glass remains constant in order to avoid the voltage anomalies that accompany durability changes. 10 p. 5c.

RP1720. Fineness test of molding sand..Margaret Price and Alexander I. Krynitsky

It is recognized that the present American Foundrymen's Association sand fineness-test method is not entirely satisfactory since sands with the same AFA classification may have different properties. In view of this fact other methods have been proposed, but in general little was published on this subject. The need for more data has prompted the present investigation. The object of this study was to evaluate the merits of the regular pipette, the Andreasen pipette, and the hydrometer methods in making fineness determinations on Albany and Lumberton molding sands. The hydrometer method which was described in detail in the paper was found to be preferable because it yields satisfactory results conveniently with a minimum expenditure of time for the operator. 21 p. 10c.

RP1721. Effect of sodium chloride on the apparent ionization constant of boric acid and the pH values of borate solutions.

George G. Manov, Nicholas J. DeLollis, Phoebe W. Lindvall, and S. F. Acree

The pH values for solutions of borax (sodium tetraborate decahydrate) and sodium chloride were determined from 0° to 60°C by the method of cells without liquid junction. In one series, the effect of sodium chloride on the apparent ionization constant of boric acid was determined by measurements of cells in which the concentration of borax was maintained constant (0.01*m*) while that of the sodium chloride was varied. In a second series, the pH values of various concentrations of borax in 0.01-*m* sodium chloride were measured, and in a third, similar measurements were made of solutions containing 0.025-*m* borax with a variable concentration of chloride.

The values of other investigators for the pH of solutions of borax in which cells with liquid junctions were involved are compared with those currently reported. Some of these are modified to take cognizance of present-day views concerning electrolytic dissociation.

A 0.01-*m* solution of borax (3.81 g of borax per liter of solution) is recommended for the calibration of pH equipment. The equation

$$\text{pH} = 2331.7/T + 0.017433T - 3.840,$$

where *T* is the absolute temperature, represents the pH values for this solution from 0° to 60°C. 16 p. 5c.

RP1722. Heats, equilibrium constants, and free energies of formation of the mono-olefin hydrocarbons.

John E. Kilpatrick, Edward J. Prosen, Kenneth S. Pitzer, and Frederick D. Rossini

For ethylene, propylene, each of the four butenes, six pentenes, and 17 hexenes, and for the higher normal 1-alkenes, values are presented for the following thermodynamic properties to 1,000° or 1,500°K: The heat of formation from the elements,  $\Delta H_f^\circ$ ; the free energy of formation from the elements,  $\Delta F_f^\circ$ ; and the logarithm of the equilibrium constant of formation from the elements,  $\log_{10} K_f$ . For each of the 6 pentenes and 17 hexenes, values are also given to 1,000° or 1,500°K, for the following prop-



erties: The heat-content function,  $(H^\circ - H_0^\circ)/T$ ; the free-energy function,  $(F^\circ - H_0^\circ)/T$ ; the entropy,  $S^\circ$ ; the heat content,  $H^\circ - H_0^\circ$ ; and the heat capacity,  $C_p^\circ$ .

Equilibrium constants and concentrations are given in tabular and graphical form for the isomerization of the 4 butenes, 6 pentenes, and 17 hexenes, as a function of the temperature to 1,000° or 1,500°K. Equilibrium constants are also given in tabular and graphical form for some reactions of hydrogenation, dimerization, and alkylation. 54 p. 10c.

Title page and contents for volume 36. 7 p. 5c.

RESEARCH PAPERS FROM JOURNAL OF RESEARCH OF THE NATIONAL BUREAU OF STANDARDS, VOLUME 37, JULY—DECEMBER 1946

RP1723. Radio proximity fuze design. . Wilbur S. Hinman, Jr., and Cleo Brunetti

The general principles governing the design of radio proximity fuzes are presented. The paper deals primarily with fuzes for smooth-bore projectiles, such as bombs, rockets and mortars. Illustrations and descriptions of the various fuzes in this category which were developed during World War II are given. Within security regulations, there is a reasonably detailed discussion of the performance and construction of fuze components, such as the oscillator, the amplifier, the antennas, the power supply and the safety and arming mechanisms. There is also a brief description of production practices and problems and methods of inspection and quality control. 13 p. 10c.

RP1724. Assembly, testing, and operation of laboratory distilling columns of high efficiency. . . . . Charles B. Willingham and Frederick D. Rossini

A description is given of the assembly, testing, and operation of the laboratory distilling columns used at the National Bureau of Standards in the work of the American Petroleum Institute Research Project 6 on the analysis and purification of hydrocarbons and in the work on the preparation of NBS Standard Samples of hydrocarbons. The following topics are covered: Assembly of distilling columns, including pot, rectifying section, jacket, head, reflux regulator, receiving assembly, electrical heating system, thermometric systems, and controlled-pressure system; testing of distilling columns, including test mixtures and results; and operation of columns, for both regular and azeotropic distillations. Drawings of the equipment and apparatus are given, including the arrangement of the 15 distilling columns, measuring instruments, and auxiliary equipment in the distillation room. A view of the distillation room is given. 15 p. 10c.

RP1725. Nickel plating on steel by chemical reduction.

Abner Brenner and Grace E. Riddell

A process has been developed for the production of adherent nickel deposits of good quality on steel without the use of an electric current. The deposition of nickel is brought about by chemical reduction of a nickel salt with hypophosphites in a hot ammoniacal solution. The reaction is catalytic and, under the prescribed conditions of concentration and pH, no reduction occurs in the solution unless certain metals, such as steel or nickel, are introduced into the bath. The reduction then occurs only at the surface of the immersed metal with the production of a coating of nickel of 96 to 97 percent purity. 4 p. 5c.

RP1726. Temperature coefficients for proving rings.

Bruce L. Wilson, Douglas R. Tate, and George Borkowski

Proving rings for calibrating testing machines are not compensated for change in elastic properties and dimensions with temperature. For this reason, temperature-correction factors must be used in computing ring loads from deflections obtained at temperatures that differ from the temperature of calibration. Temperature coefficients for 14 representative rings were computed from calibration results obtained at temperatures of 70° and 100° F. The temperature coefficient of one ring for the range + 70° to - 93°F was determined from measurements of the natural frequencies at these temperatures. The temperature coefficient of a proving ring is shown to be equal to the temperature coefficient of Young's modulus of elasticity plus twice the coefficient of thermal expansion of the material of the ring. 7 p. 10c.

RP1727. Mutarotation and ring structure of mannuronic lactone.

Horace S. Isbell and Harriet L. Frush

The numerous commercial applications of algin, a polysaccharide derived from certain marine plants, makes important the study of its principal constituent, D-mannuronic lactone. In this paper it is shown that by oxidation with bromine mannosaccharic dilactone of known structure is formed directly from mannuronic lactone without change in ring structure, and hence the latter substance, like mannosaccharic

dilactone, has a bicyclic structure consisting of two butylene oxide rings. The initial rapid mutarotation reaction of the substance is shown to consist of a conversion of the beta furanose modification to an equilibrium mixture containing the alpha furanose, and a detectable amount of the aldehyde modification. There is a small but measurable displacement of equilibrium with change in temperature. The mutarotation is exceptionally sensitive to basic catalysts and for this reason the point of minimum rate lies in the acid region at pH 3.1. 7 p. 5c.

RP1728. Heats of formation and combustion of the normal alkylcyclopentanes and cyclohexanes and the increment per  $\text{CH}_2$  group for several homologous series of hydrocarbons.

Edward J. Prosen, Walter H. Johnson, and Frederick D. Rossini

Values are presented for the heats of formation and combustion at  $25^\circ\text{C}$  for the normal alkylcyclopentanes and the normal alkylcyclohexanes, in the liquid state through normal butyl and in the gaseous state through normal hexadecyl, with equations to yield values for all the higher members of both series in the gaseous state.

The increment per  $\text{CH}_2$  group is compared for the lower members of several normal alkyl homologous series, including paraffins, monoolefins (1-alkene), alkylbenzenes, alkylcyclopentanes, alkylcyclohexanes, and alkyl acetylenes (1-alkyne). 6 p. 5c.

RP1729. Preliminary description and analysis of the first spectrum of uranium.

C. C. Kiess, Curtis J. Humphreys, and Donald D. Laun

Observations of the spectra emitted by uranium under arc and spark excitation have afforded a separation of the lines of neutral atoms from those emitted by ions. A list of more than 9,000 lines with accurate wavelengths, wave numbers, and estimated intensities, for the region 2900 Å to 11000 Å, has been compiled as descriptive of the spectrum of the neutral atom. About 2,000 of these lines have been classified as combinations between 18 low and metastable odd energy levels with about 280 high even levels. Well-resolved Zeeman patterns give  $g$ -values for several low levels that identify them as components of  $^3\text{L}$ ,  $^3\text{K}$ ,  $^7\text{M}$ , and  $^7\text{K}$  terms arising in the electron configurations  $f^2ds^2$  and  $f^3d^2s$ . The spectrum of uranium is interpreted as that of a rare-earth element analogous to neodymium, uranium being the third member of a second group of rare earths beginning with thorium. From the fact that uranium is easily ionized in electric arcs and magnetic fields, and also that the short-wave limit of the observed spectrum does not extend below 2900 Å, it is concluded that the ionization potential of neutral uranium atoms is approximately 4 volts. 16 p. 10c.

RP1730. Viscosity and the extraordinary heat effects in glass....Arthur Q. Tool

In accordance with experience concerning the behavior of glass at temperatures within its annealing range, an equation is proposed that relates the various extraordinary heat effects to the inelastic deformability and to the degree of superheating or undercooling. By using this equation in connection with the thermal-expansion curves of a glass within its annealing range, certain constants that are related to the coefficient of viscosity and its changes with temperature and the degree of superheating or undercooling have been determined with reasonable results. Such results make it possible to estimate the inelastic deformability of a glass in its various conditions at all annealing temperatures and are, therefore, valuable in connection with problems that are encountered in the process of annealing glass. The apparent success achieved in applying the proposed equation to experimental data suggests that the concepts underlying this equation are fundamental and must be considered in any theory concerning the constitution of glass or that of any other extremely viscous liquid. 18 p. 10c.

RP1731. An arrangement with small solid angle for measurement of beta rays.

Leon F. Curtiss and Burrell W. Brown

An arrangement using a Geiger-Müller counter with small aperture with a radioactive source at some distance from it is described for counting beta particles. Sources emitting only beta rays with maximum energies above 1 million electron volts of the order of 1 millicurie can be measured in terms of the disintegration rate from the observed counting rate and the solid angle as calculated from the dimensions of the apparatus. An independent check of the arrangement shows that this can be done reliably. A suggestion for discarding the use of the curie and substituting a unit consisting of  $10^6$  disintegrations per second to be called the "rutherford" is made. The curie is properly applicable only to members of the radium family. 4 p. 5c.



RP1732. Heats, equilibrium constants, and free energies of formation of the alkylbenzenes.

William J. Taylor, Donald D. Wagman, Mary G. Williams, Kenneth S. Pitzer, and Frederick D. Rossini

For benzene, toluene, ethylbenzene, the three xylenes, normal and isopropylbenzene, the three methylethylbenzenes, the three trimethylbenzenes, and the higher normal alkylbenzenes, values are presented for the following thermodynamic properties for the gaseous state to 1,500°K: The heat-content function,  $(H^\circ - H_0^\circ)/T_0$ ; the free-energy function,  $(F^\circ - H_0^\circ)/T$ ; the entropy,  $S^\circ$ ; the heat content,  $H^\circ - H_0^\circ$ ; the heat capacity,  $C_p$ ; the heat of formation from the elements,  $\Delta H_f^\circ$ ; the free energy of formation from the elements,  $\Delta F_f^\circ$ ; and the logarithm of the equilibrium constant of formation from the elements,  $\log_{10} K_f$ .

Equilibrium constants and concentrations are given in tabular and graphical form for the isomerization of the four  $C_8H_{10}$  alkylbenzenes and for the eight  $C_9H_{12}$  alkylbenzenes as a function of the temperature to 1,500°K. Equilibrium constants are also given in tabular and graphical form for some reactions involving alkylation (addition of olefin to benzene to form alkylbenzene), cyclization (conversion of paraffin to alkylbenzene plus hydrogen), and trimerization (of acetylene to form benzene and of methylacetylene to form 1,3,5-trimethylbenzene). 28 p. 15c.

RP1733. A study of the damaging effect of fatigue stressing on SAE X4130 steel.

John A. Bennett

The damaging effect of fatigue stressing above the endurance limit was investigated with notched specimens of SAE X4130 steel. The damage was measured by the decrease in endurance at another stress. A deflection method for detecting the formation of a fatigue crack permitted the damage measurement to be limited chiefly to the precrack stage. The results showed that the apparent rate of damage depends on the stress history. If the prestress is higher than the test stress, the damage occurs rapidly at first, then more slowly. The reverse is true if the damaging stress is lower than that used to measure the damage.

Tests also were made with smooth specimens in an effort to determine the cumulative damage caused by fatigue at more than one stress. Two methods were developed for extrapolating to determine the point at which fatigue cracking starts, so the damaging cycle ratios could be based on the life of the specimens prior to cracking. Complete *S-N* curves were determined for specimens after each of eight different damaging treatments. With these curves a method of expressing damage was developed that permitted the direct addition of damage occurring at different stresses. The reliability of this method was checked by testing specimens after fatigue loading at two or more different stresses and comparing the results with predictions based on the addition of the indicated damage. The agreement was within the experimental error. 17 p. 10c.

RP1734. Purification, purity, and freezing points of 31 hydrocarbons of the API-NBS series.

Augustus R. Glasgow, Jr., Evelyn T. Murphy, Charles B. Willingham, and Frederick D. Rossini

This report describes the purification and determination of freezing points and purity of 31 hydrocarbons of the API-NBS series, including 2 pentanes, 5 hexanes, 2 heptanes, 1 octane, 3 alkylcyclopentanes, 3 alkylcyclohexanes, and 15 alkylbenzenes. 5 p. 10c.

RP1735. Absorption measurements for broad beams of 1- and 2-million-volt X-rays.

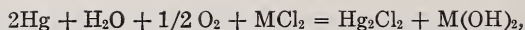
George Singer, Carl B. Braestrup, and Harold O. Wyckoff

Experimentally determined concrete-absorption curves are given for wide-angle X-ray beams produced by a 1- and 2-million-volt resonance generator. Data on the variation of X-ray intensity with the distance from a concrete barrier are included. With this information as a basis, the thickness of a concrete barrier necessary for protection against a broad X-ray beam has been computed for 1- and 2-million-volt X-rays and for various tube currents and barrier-to-target distances. 4 p. 10c.

RP1736. Effect of reaction between mercury and oxygen upon polarographic waves of certain metals at small concentrations.

Edgar Reynolds Smith, John Keenan Taylor, and Roberta Evelyn Smith

Polarographic waves of certain metals, notably of lead, zinc, copper, cobalt, and nickel in dilute neutral solutions, diminish progressively with time in the presence of mercury and air. This behavior is not to be explained by adsorption, as has previously been supposed, but by a reaction between mercury, water, oxygen, and the ions of the metallic salt which, in some instances, precipitates the metal from solution in the form of its hydroxide. This reaction is



in which M represents the metal. Recognition of this reaction and precautions to exclude it are essential for accurate polarographic determinations of small amounts of heavy metals. 5 p. 10c.

RP1737. Theory for axial rigidity of structural members having ovaloid or square perforations.....Martin Greenspan

Formulas are derived for computing the over-all lengthening (or shortening) of a tension (or compression) member having a uniform gross cross section and a series of similar perforations of approximately ovaloid or approximately square shape uniformly distributed along the length. 5 p. 10c.

RP1738. Heat content, free-energy function, entropy, and heat capacity of ethylene, propylene, and the four butenes to 1,500°K.

John E. Kilpatrick and Kenneth S. Pitzer

Values are presented for the following thermodynamic properties for ethylene, propylene and the four butenes, in the ideal gaseous state, to 1,500°K: heat-content function,  $(H^\circ - H_0^\circ)/T$ ; free-energy function,  $(F^\circ - H_0^\circ)/T$ ; entropy,  $S^\circ$ ; heat content,  $(H^\circ - H_0^\circ)$ ; heat capacity,  $C_p^\circ$ . 9 p. 10c.

RP1739. A simple cyclic falling-film molecular still.....John Keenan Taylor

The efficient cyclic falling-film molecular still described is characterized by simplicity of operation and ease of construction. The liquid to be distilled is pumped from the reservoir and introduced on the vertical cylindrical evaporator by an annular orifice. The resulting uniform distribution of the distilland, together with the short column used, makes for efficient operation. The apparatus may be used for charges of liquid ranging from a minimum of about 10 ml to 1 liter or more. 4 p. 5c.

RP1740. A study of resinous sealants for porous metal castings..Vernon C. F. Holm

The repair of porous castings by sealing with liquid synthetic resins was investigated. The sealing efficiencies of fourteen resins were determined on porous bushings of aluminum, a copper-silicon alloy, and a red brass, impregnated by the vacuum-pressure method. Tests were made to determine the durability of the two most promising sealants by exposing specimens sealed with these resins to hot motor oil, high octane gasoline, boiling water elevated temperatures, high pressures, and thermal shock. The results suggest that this procedure for rendering porous castings pressure tight may be permissible in emergencies but that, in general, the foundryman should exert every effect to produce non-porous castings instead of trying to remedy porosity. 6 p. 10c.

RP1741. Testing large-capacity rotary gas meters.

Howard S. Bean, Matthew E. Benesh, and Frank C. Witting

The paper describes two methods of testing rotary gas meters of large capacity. In one method, known as the field test method, the necessary equipment is taken to the meter location. In the other method, termed the "transfer method," the test is made in a shop where conditions can be controlled more closely. Results obtained by the two methods are compared.

Tests made to study the instantaneous pressures within the closed measuring pockets of rotary meters and the effect of pulsations at the meter inlet are described, and the results discussed. 27 p. 15c.

RP1742. Poisson's ratio of some structural alloys for large strains.

Ambrose H. Stang, Martin Greenspan, and Sanford B. Newman

Values of Poisson's ratio, as well as ordinary stress-strain properties, for tensile strains as high as 18 percent, were determined on sheets of aluminum alloys 24ST and 24SRT, chrome-molybdenum steel plate, and structural and fully killed low-carbon steel plate. 11 p. 10c.

RP1743. Electrode function (pH response) of potash-silica glasses...Donald Hubbard

The electrode function (pH response) of a series of potash-silica ( $\text{K}_2\text{O}-\text{SiO}_2$ ) glasses was determined and a comparison made with the hygroscopicity of the glasses. All the  $\text{K}_2\text{O}-\text{SiO}_2$  glasses investigated showed a very high hygroscopicity, with an accompanying sensitive pH response. However, between pH 2 and 4, glasses of 71.8 and 73.6 percent  $\text{SiO}_2$  gave pH-response values higher than the 59 millivolts per pH predictable from the Nernst equation.

Electrodes prepared from all members of the series demonstrated large voltage departures from the straight-line relation with increasing alkalinity of the buffer solutions. For a glass of 75.76 percent  $\text{SiO}_2$  content, the voltage departures were compared with the chemical durability of the glass and also with the sodium-ion concentration,



[Na<sup>+</sup>], of the Britton-Robinson universal buffer solutions used. The voltage departures correlated with the magnitude of the attack much more convincingly than with the pNa.

For several chosen pH values, the voltage departures for the electrodes of these glasses when plotted with reference to their SiO<sub>2</sub> content gave curves that indicated a sharp change in slope near 74 percent of silica. A corresponding change in slope was also shown by the hygroscopicity-percentage-silica curve. 6 p. 10c.

RP1744. Purification and sealing "in vacuum" of National Bureau of Standards Standard Samples of hydrocarbons.

Beveridge J. Mair, Domenic J. Termini, Charles B. Willingham, and Frederick D. Rossini

This report describes the procedure and apparatus used in the purification and sealing "in vacuum" of 19 National Bureau of Standards Standard Samples of hydrocarbons, including 9 paraffins, 3 cycloparaffins, and 7 alkylbenzenes. 8 p. 10c.

RP1745. Thermal-expansion stresses in reinforced plastics.....Philip S. Turner

Failure of adhesive bonds is attributed to boundary stress concentrations. An analysis of the causes of internal-stress concentrations in rigid adhesive layers leads to the conclusion that stress concentrations can be eliminated in many cases by matching the coefficients of thermal expansion of the component parts. A stress-equilibrium formula for calculating the thermal-expansion coefficients of mixtures involves the density, modulus of elasticity, coefficient of thermal expansion, and proportion by weight of the ingredients. Illustrations of the application of the derived formula include lead-antimony and beryllium-aluminum mixtures, phenol-formaldehyde resin and glass-fiber mixtures, and plastic plywoods. The thermal-expansion coefficients of a number of pure and reinforced plastics are reported. Bonds obtained when thermal coefficients are matched are stable over a wide temperature range. 12 p. 10c.

RP1746. Salt effects of potassium nitrate, sodium sulfate, and trisodium citrate on the activity coefficients of *p*-phenolsulfonate buffers.

Roger G. Bates, Pauline T. Diamond, Murray Eden, and S. F. Acree

Electromotive-force measurements of cells without liquid junction that contained hydrogen and silver-silver-chloride electrodes and alkaline *p*-phenolsulfonate buffers with added salts of different valence types were made from 0° to 60°C. The 63 buffer solutions studied were prepared by the partial neutralization of potassium *p*-phenolsulfonate with sodium hydroxide, and each contained approximately equal molal amounts of potassium *p*-phenolsulfonate and of potassium sodium *p*-phenolate sulfonate. These solutions were classified into five series on the basis of the kind of added salt and the ratio, *R*, of its molality to the molality of each buffer salt, as follows: Potassium nitrate, *R* = 1; sodium sulfate, *R* = 1; sodium sulfate, *R* = 0.5; barium chloride, *R* = 0.5; trisodium citrate, *R* = 0.33. All the buffers, with the exception of the series to which barium chloride was added, likewise contained sodium chloride, *R* = 1. The ionic strengths of the solutions varied from 0.05 to 0.8.

The values of the second dissociation constant of *p*-phenolsulfonic acid given in an earlier paper were confirmed. The influence of potassium nitrate, sodium sulfate, and trisodium citrate on the activity coefficient term,  $f_{C_1HP_3}/f_P$ , in which *f* represents an activity coefficient on the molal scale and the subscripts represent respectively chloride ion and the primary and secondary anions of the buffer, was determined for solutions containing no sodium chloride at 0° to 35°C. No pronounced differences in character were observed among the effects of the salts of the three valence types in concentrations sufficient to make up one-fifth of the ionic strength of the mixture. 11 p. 10c.

RP1747. Equilibrium constants of some reactions involved in the production of 1,3-butadiene..Ferdinand G. Brickwedde, Morris Moskow, and John G. Aston

Thermodynamic functions including free energy, enthalpy, entropy, and specific heat, are given for the compounds butadiene, benzene, cyclohexane, ethane, ethylene, ethyl alcohol and water and for the elements carbon (graphite), hydrogen and oxygen. From these are calculated and tabulated values of equilibrium constants for reactions of interest in connection with the production of 1,3-butadiene for synthetic rubber. Comparisons are made between table values and available experimental data on equilibrium constants, gaseous specific heats and entropies. The cracking of hydrocarbons is discussed and the importance of reaction rates in determining the amounts of reaction products is noted. 16 p. 10c.

RP1748. Effect of catalysts and pH on strength of resin-bonded plywood.  
Gordon M. Kline, Frank W. Reinhart, Royden C. Rinker, and Nicholas J. DeLollis

The effects of various catalysts used to cure the resinous adhesives on the strength properties of plywood were investigated, particularly with regard to the degree of acidity developed by the catalysts in the resin film and in the plywood. The flexural, impact, and shear strengths, both initially and after aging, of birch plywoods bonded with urea-formaldehyde and phenol-formaldehyde resins definitely decrease as the acidity of the plywood increases, as evidenced by a decrease in pH. Only in the case of plywood bonded with casein and urea-formaldehyde resins had the deterioration at the bond progressed sufficiently in the roof-agent tests to make it impossible to carry out strength tests because of delamination. A correlation between decrease in strength on aging of plywood bonded with alkali-catalyzed phenolic acid and increase in alkalinity of the panel was observed. Because of the different absorption capacities of the phenolic resins for acids and alkalies, it is not possible to predict the pH of plywood panel from the pH of the resin film.

The susceptibility of birch wood, itself, to attack by acids and alkalies was determined in order to better understand the mechanism of the deterioration of resin-bonded plywood. A marked decrease in strength occurred when the pH of the wood was lowered below 2.0. In the range between pH 2.0 and 2.5, strong acids, such as hydrochloric and sulfuric, had a more pronounced deteriorating effect than weak acids, such as hypophosphorous and nitranilic. A marked decrease in strength of the birch also occurred when the pH was raised to 8.8 by the absorption of an alkali, tetraethanolammonium hydroxide. 29 p. 15c.

RP1749. Purification of sodium chloride and potassium chloride for use in electrochemical work, and the determination of small amounts of bromide.  
Gladys D. Pinching and Roger G. Bates

The effects of small amounts of dissolved impurities on the potentials of silver-silver-halide electrodes immersed in solutions of alkali halides were studied. Traces of bromide exert disturbing effects on the potential of the silver-silver-chloride electrode. A convenient method for determining small amounts of bromide in the presence of chlorides and a satisfactory means of purifying sodium and potassium chlorides for precise electrochemical work are outlined. The procedure involves treatment of a saturated solution of the salt with chlorine, two successive precipitations with hydrogen chloride, and fusion of the air-dried product. A method for diminishing hydrolysis of the salts during fusion is described. 8 p. 10c.

RP1750. Preparation of mannuronic lactone from algin.  
Harriet L. Frush and Horace S. Isbell

A simple procedure is reported for the preparation of crystalline mannuronic lactone from algin. The algin is converted to alginic acid, which is hydrolyzed by the action of concentrated sulfuric acid followed by dilute acid. In contrast to prior methods, the lactone is crystallized directly from the hydrolyzate of alginic acid without the intermediate separation of the amorphous barium salt or the cinchonine salt. The yield is from 25 to 30 percent of the alginic acid used. The preparation and properties of crystalline sodium mannuronate and potassium mannuronate monohydrate are also described. 4 p. 10c.

RP1751. Experimental manufacture of paper for war maps.  
Charles G. Weber and Merle B. Shaw

Early in World War II, a new map paper was developed that greatly improved the quality and performance of war maps. The National Bureau of Standards cooperated in the development and, subsequently, determined by experimental manufacture how to make the paper from commercially available raw materials. The best results were obtained in experimental manufacture by using fiber furnishes of 100-percent strong bleached sulfate pulps with the addition of melamine-formaldehyde resin to increase the wet strength and titanium dioxide to produce the desired opacity. It was essential that the beating be very carefully controlled to preserve the maximum fiber strength. The most critical requirements from a manufacturing standpoint were very high resistance to tear, high wet tensile strength, high opacity, and good smoothness. A moderate degree of wildness was not objectionable. The data obtained by experiments were applied to initiate the commercial production of the new paper to meet unprecedented tonnage requirements. 5 p. 10c.



RP1752. Purification, purity, and freezing points of 7 heptanes, 16 octanes, 6 pentenes, cyclopentene, and 7  $C_9H_{12}$  alkylbenzenes of the API-Standard and API-NBS series.

Anton J. Streiff, Evelyn T. Murphy, Vincent A. Sedlak, Charles B. Willingham, and Frederick D. Rossini

This report describes the purification and determination of freezing points and purity of 37 hydrocarbons of the API-Standard and API-NBS series, including 7 heptanes, 16 octanes, 6 pentenes, cyclopentene, and 7  $C_9H_{12}$  alkylbenzenes. 47 p. 20c.

RP1753. Carrier-distillation method for spectrographic analysis and its application to the analysis of uranium-base materials.

Bourdon F. Scribner and Harold R. Mullin

A method of fractional distillation in the direct-current arc was developed for the spectrographic determination of 33 volatile impurity elements at concentrations as low as a fraction of a part per million in uranium-base materials. The method involves (1) the conversion of the sample matrix to a form having low volatility, (2) the addition of a small amount of a selected volatile "carrier" material, and (3) partial distillation of the mixture in a direct-current arc with an electrode assembly of improved design. In the analysis of uranium-base materials, the sample was converted to the oxide  $U_3O_8$  and gallium oxide was added as a carrier (2 parts  $Ga_2O_3$ , 98 parts  $U_3O_8$ ). The procedure was applied to the determination of Ag, Al, As, Au, B, Ba, Be, Bi, Cd, Co, Cr, Cs, Cu, Fe, Ge, Hg, In, K, Li, Mg, Mn, Mo, Na, Ni, P, Pb, Rb, Sb, Si, Sn, Tl, V, and Zn. Repeated results for B, Cd, Si, Fe, Mg, and Mn, determined photometrically, agreed within  $\pm 10$  percent. The high sensitivity and general applicability of the method are results of the characteristic that the refractory sample matrix is not volatilized appreciably, during the period that the minute quantities of impurity vapors are swept into the arc by the carrier. 10 p. 10c.

RP1754. Vacuum-tube acceleration pickup.....Walter Ramberg

The vacuum-tube acceleration pickup consists of a fixed indirectly heated cathode and two plates on either side of the cathode which are mounted elastically to deflect in response to acceleration normal to the plane of the plates. The tube has a natural frequency of about 800 cycles per second, and it has a flat response for sinusoidal accelerations from 0 to 200 cycles per second with enough output at accelerations of the order of 10 g to drive a recording galvanometer directly without the complications of an amplifier. The use of the tube is recommended in those applications in which its peculiar advantages of high natural frequency, ability to withstand large accelerations, and linearity outweigh the disadvantages of zero drift, warming-up time, high current consumption, and the need of filtering to remove natural frequency response. 7 p. 15c.

RP1755. Comparative bond efficiency of deformed concrete reinforcing Bars.

Arthur P. Clark

The purpose of the tests was to determine the resistance to slip in concrete of 17 different designs of deformed reinforcing bars.

The tests were of the pull-out type in which the bars were cast in a horizontal position; the depth of concrete under the bars and the length of embedment were varied. The slip of the bar was measured at the loaded and free ends.

Three tests were made of each variable for each design of deformation.

It was established that a certain group of the bars was definitely superior to the others, in the sense that their average rating was significantly higher than the average of the others. Bars cast in the top position were much less effective than those cast in the bottom position. 8 p. 10c.

RP1756. Development of a hydrochloric acid process for the production of alumina from clay.

James I. Hoffman, Robert T. Leslie, Harold J. Caul, Lewis Jesse Clark, and John Drake Hoffman

The development of a process for the extraction of alumina from clay and the construction of a pilot plant are described.

The process consists in (1) roasting clay at about  $700^{\circ}C$ , (2) digesting the roasted product with dilute hydrochloric acid, (3) filtering to separate the insoluble siliceous matter from the solution containing the aluminum and soluble impurities, such as iron and alkali salts, (4) concentrating the solution, (5) precipitating the aluminum as the hydrated chloride from the concentrated solution by adding hydrochloric acid gas, (6) removing the crystals of hydrated aluminum chloride, (7) washing the crystals to remove adhering impurities, (8) calcining the hydrated chloride to obtain alumina, and (9) recovering hydrochloric acid from the waste products at the end of the process.

The operation of the pilot plant shows that the process is feasible for the production of alumina from clay but that the alumina costs more than that produced from bauxite by the present well-known processes. 19 p. 15c.

RP1757. Study of Ofner's method for the determination of invert sugar.

Emma J. McDonald and Anne L. Turcotte

In a previous investigation Jackson and McDonald studied Ofner's method for the determination of invert sugar in sucrose. They modified the procedure and were thus able to increase the reproducibility of results when determining from 5 to 25 mg of invert sugar in the presence of sucrose. This method has now been applied to pure invert sugar and to sugar samples containing 5 mg or less of invert sugar in 10 g of sucrose. It has proved to be a suitable method for the analysis of high-grade refined sugars as well as for the determination of 25 mg or less of invert sugar alone. A table is given for the conversion of milliliters of iodine consumed to milligrams of invert sugar present. 5 p. 10c.

Title page and contents for volume 37. 5 p. 5c.

RESEARCH PAPERS FROM JOURNAL OF RESEARCH OF THE NATIONAL BUREAU OF  
STANDARDS, VOLUME 38, JANUARY—JUNE 1947

RP1758. Vibrational frequencies of semirigid molecules: a general method and values for ethylbenzene.....William J. Taylor and Kenneth S. Pitzer

It is shown that in normal coordinate calculations of the vibrations of molecules it is sometimes advantageous to calculate the kinetic-energy matrix, rather than the reciprocal kinetic-energy matrix. Explicit formulas are given for the elements of the kinetic-energy matrix. Illustrative calculations are given for propane, toluene, and ethylbenzene. A semiempirical assignment of the vibration frequencies of ethylbenzene is made on the basis of these calculations and the spectroscopic data. 17 p. 15c.

RP1759. Analysis of a standard sample of natural gas by laboratories cooperating with the American Society for Testing Materials...Martin Shepherd

This is a report of the analysis of a standard sample of natural gas by 30 laboratories cooperating with Subcommittee VII of Committee D-3 of the American Society for Testing Materials. The data are presented in a series of frequency distribution plots that show at a glance how the analyses from all laboratories compare with respect to each component determined, as well as calculated heating value and specific gravity. The heating value and specific gravity determined by analysis are compared with values carefully measured at the National Bureau of Standards. The analyses were performed volumetrically by the absorption and combustion methods, and the plots form a clear picture of this type of gas analysis in this country. Although some very creditable work is reported, the need for standardization is evident. 33 p. 20c.

RP1760. Purification, purity, and freezing points of 8 nonanes, 11 alkylcyclopentanes, 6 alkylcyclohexanes, and 4 butylbenzenes of the API-Standard and API-NBS series.

Anton J. Streiff, Evelyn T. Murphy, Janice C. Cahill, Helen F. Flanagan, Vincent A. Sedlak, Charles B. Willingham, and Frederick D. Rossini

This report describes the purification and determination of freezing points and purity of 29 hydrocarbons of the API-Standard and API-NBS series, including 8 nonanes, 11 alkylcyclopentanes, 6 alkylcyclohexanes, and 4 butylbenzenes. 42 p. 20c.

RP1761. Infrared absorption spectra of some experimental glasses containing rare earth and other oxides.....Ralph Stair and Conrad A. Faick

This paper gives spectral transmission data on soda lime glass containing rare earth (Y, Pr, Nd, Sm, Gd, Er) or other coloring oxides (V, Cr, Mn, Co, Ni, U) in the spectral region of 0.7 to 4.5 microns. 7 p. 10c.

RP1762. Properties of water-repellent fabrics.

John W. Rowen and Domenick Gagliardi

A review and an analysis of the theory of water repellency of textile fabrics have been made. The physicochemical basis underlying the wettability, or water repellency, of treated fabrics is discussed. A survey of the laboratory test methods for evaluating water repellency of textile fabrics is presented. A study was made of the water-repellent properties of 11 commercial raincoat and 4 military fabrics. For this study two of the more recent test methods were examined, the drop-penetration and the contact-angle tests. Two other, and older, test methods were also studied, the spray-rating and the hydrostatic-pressure tests. Several exploratory observations were made in an attempt to determine the mechanism by which water-repellent fabrics lose their repellency when exposed to rain. 15 p. 10c.



RP1763. Adsorption of water vapor by untanned hide and various leathers at 100°F.

Joseph R. Kanagy

Adsorption of water vapor by untanned hide and various tannages of leather was determined at relative humidities ranging from 0 to 96 percent of 100°F. The Brunauer, Emmett, and Teller equations for adsorption of gases in multimolecular layers were applied to the data. Adsorption for all of the samples below a relative humidity of 75 percent is a function of the available surface. Above 75 percent relative humidity, other factors exert an influence, the most important of which is probably size of the capillaries. Untanned hide and chrome tanned leather adsorb the most water vapor except at relative humidities above 75 percent at which sole leather adsorbs more. The behavior of the sole leather in this region is ascribed to the presence of deliquescent materials used in the finishing process. The other vegetable-tanned leathers adsorb less moisture than either hide or chrome leather. Calculated heats of adsorption indicate that the affinity of groups for water is not appreciably altered by tanning and that the adsorption is physical in nature. Methods by which the data may be applied to practical processes, such as fatliquoring and tanning, are pointed out. 17 p. 10c.

RP1764. Concentration of the isotopes of mercury by free evaporation in a 10-cell counter-current reflux still.

A. Keith Brewer and Samuel L. Madorsky

Concentration of the isotopes of mercury was carried out in a counter-current molecular still consisting of 10 stages. Distillation temperatures varied from 55° to 100°C. A single-stage molecular still was operated, also with mercury, at temperatures varying from 108.1° to 128°C with those obtained previously by other investigators operating with single-stage stills. 7 p. 10c.

RP1765. Concentration of isotopes of potassium by the counter-current electromigration method.

A Keith Brewer, Samuel L. Madorsky, John Keenan Taylor, Vernon H. Dibeler, Paul Bradt, O. Lee Parham, Roy J. Britten, and J. Gilman Reid, Jr.

A new electromigration method for the separation of isotopes is described. This method is based on the principle of setting up a flow of electrolyte through a packed column in a direction countercurrent to the flow of the isotopic ions being separated and at a rate intermediate between the velocities of these ions. Under these conditions, the faster moving ions will make headway against the electrolyte stream while the slower moving ions will be carried back. The separation coefficient  $\epsilon - 1$  in the case, for example, of cations, is given as equal to  $FV_c C \ln S / 1000 I^+ t$ , where  $F$  is the Faraday constant,  $V_c$  is cathode volume in cubic centimeters,  $C$  is normality of the electrolyte,  $S$  is separation factor,  $I^+$  is positive ion current and  $t$  is time in seconds. Free space and temperature distribution in the packing, balance between ion transport and stream counter-flow and other factors which determine column efficiency, are described. In a series of experiments for the concentration of  $^{39}\text{K}$  in the cathode compartment of the electromigration cell, the abundance ratio  $N = ^{39}\text{K}/^{41}\text{K}$  was increased from its normal value of 14.2 to a maximum of 24 in about 500 hours of operation and a maximum separation coefficient of  $0.385 \times 10^{-2}$  was obtained. Attempts to concentrate  $^{41}\text{K}$  in the anode compartment resulted in a lowering of the isotope abundance ratio to a minimum of 9.1. A study of the distribution of  $^{39}\text{K}$  in the packing in experiments carried out for the concentration of  $^{39}\text{K}$  in the cathode compartment, showed that the abundance ratio decreases rapidly from the cathode to anode direction. A description is given of the mass-spectrometer used in measuring the abundance ratio  $^{39}\text{K}/^{41}\text{K}$ , also, of the automatic control used in regulating the counter-flow in some of the electromigration cells. 32 p. 15c.

RP1766. Concentration of  $^{39}\text{K}$  by countercurrent electromigration: Some theoretical aspects of the operation.....James W. Westhaver

Equations are derived which describe the operation (A), for the early stages of the run, (B), after infinite time with no production, and (C), after infinite time at fixed production. The formulas under (A) enable evaluation of the elementary separation coefficient,  $\epsilon$ . Those under (B) enable calculation of the maximum separation in terms of various channeling factors which determine the length of theoretical unit cell,  $h$ . The formulas under (C) enable calculation of optimum production conditions. When measured by the smallness of  $h$ , the analysis depicts the fractionator as one which is about 100 times more powerful than a modern laboratory distillation column. 15 p. 10c.

RP1767. Concentration of isotopes of chlorine by the countercurrent electromigration method.....Samuel L. Madorsky and Sidney Straus

The isotope  $^{35}\text{Cl}$  was concentrated in the anode compartment of an electromigra-

tion cell, with NaCl as the electrolyte. The operation was regulated by means of a stationary boundary between solutions of NaOH and NaCl as the lower and upper liquids, respectively. A concentration of  $^{35}\text{Cl}$  from the normal value of 75.76 percent to a minimum value of 80.7 percent was obtained in 474 hours. The maximum initial separation coefficient,  $\epsilon - 1$ , was  $0.207 \times 10^{-2}$ . 5 p. 10c.

RP1768. Normal coordinate analysis of the vibrational frequencies of ethylene, propylene, *cis*-2-butene, *trans*-2-butene, and isobutene.

John E. Kilpatrick and Kenneth S. Pitzer

The secular equations for the vibrations of ethylene, propylene, *cis*-2-butene, *trans*-2-butene, and isobutene have been derived and have been factored to the greatest possible extent. A potential expression has been fitted to an assignment of vibrational frequencies for ethylene and deuterioethylene. Some of the constants so determined have been used in deriving approximate potential expressions for propylene, *cis*-2-butene, *trans*-2-butene, and isobutene. With the vibrational frequencies calculated from these potential expressions as a guide, frequency assignments have been made for propylene, *cis*-2-butene, *trans*-2-butene, and isobutene. 19 p. 15c.

RP1769. Infrared absorption spectra of twelve cyclopentanes and cyclohexanes. Earle K. Plyler, Ralph Stair, and Curtis J. Humphreys

The infrared absorption spectra of seven cyclopentanes and five cyclohexanes have been measured in the region from 2 to 15 microns. The substances were cyclopentane, methylcyclopentane, 1,1-dimethylcyclopentane, *trans*-1,2-dimethylcyclopentane, *trans*-1,3-dimethylcyclopentane, *cis*-1,2-dimethylcyclopentane, and *cis*, *trans*, *cis*-1,2,4-trimethylcyclopentane, also cyclohexane, methylcyclohexane, 1,1-dimethylcyclohexane, *trans*-1,2-dimethylcyclohexane, and *cis*-1,2-dimethylcyclohexane. The wavelengths of all the observed absorption bands are given in a table, and a graph is shown of the percentage transmission over the wave length region of each substance. The hydrocarbons were highly purified in the chemistry division and these spectra will be of value as a check on the purity of these compounds which may be obtained from other sources. Also the more intense bands serve as a means of identification. For each substance the bands that are best suited for distinguishing it are noted.

Of special interest are the four dimethylcyclopentanes which were studied. The structural positions of the substituted methyl groups differ only slightly, but the spectral difference is quite marked. The infrared absorption spectra are well suited to show characteristic differences between isomers.

The measurements were made with a Perkin-Elmer spectrometer with a General Motors amplifier and Brown recorder. A slit control mechanism is described in detail. Although the slit control gear arrangement is relatively simple, the results obtained with it are good. The energy output is held nearly constant from 3.5 to 14.5 microns. 18 p. 15c.

RP1770. Elastic behavior and creep of refractory bricks under tensile and compressive loads.....Lewis E. Mong

Nine brands of firebrick, including two high alumina, four fire clay, two siliceous, and one silica, were subjected to creep tests. Specimens were cut from 9-inch bricks. Creep tests, with either tensile or compressive stresses, were made at 11 temperatures from 25° to 950°C, inclusive. Durations of tests were approximately 240 days. Small length changes, independent of stress direction, occurred at the lower temperatures. Lowest temperatures at which creep was significant were: high alumina, 700° to 850°C; fire clay, 600° to 700°C; siliceous and silica, 950°C. Creep results with compressive stresses could not be correlated with results with tensile stresses. At 950°C, specimens of different brands showed greatly different capacities to carry load. Repeated heatings caused growth of silica brick. Moduli of elasticity at room temperature were determined before and after the various heat treatments, and resultant changes in moduli are recorded. The changes were large for silica brick and small for the fire-clay brick. 12 p. 10c.

RP1771. Surface tensions of some optical glasses. Leo Shartsis and Alden W. Smock

The surface tension of a number of optical glasses made at the National Bureau of Standards was measured by a modification of the anchor-ring method. At 1,300°C, the values for the flint glasses were in the range 210 to 230 dynes/cm; those for the barium-crown glasses were 260 to 310; the other types of glasses had intermediate values. Most of the glasses had positive temperature coefficients of surface tension. The surface-tension values increased with increasing periods of time. The glasses were maintained at elevated temperatures immediately prior to measurement. Positive rank correlation coefficients of statistical significance were found between seed quality of optical glasses and such factors as surface tension, pot attack, and amount of gas liberated during the melting process. 10 p. 10c.



RP1772. Laminar boundary-layer oscillations and transition on a flat plate.

Galen B. Schubauer and Harold K. Skramstad

This is an account of an investigation conducted at the National Bureau of Standards, with the cooperation and financial assistance of the National Advisory Committee for Aeronautics, in which oscillations were discovered in the laminar boundary layer along a flat plate. These oscillations were found during the course of an experiment in which transition from laminar to turbulent flow was being studied on the plate as the turbulence in the wind stream was being reduced to unusually low values by means of damping screens. The first part of the paper deals with experimental methods and apparatus, measurements of turbulence and sound, and studies of transition. A description is then given of the manner in which oscillations were discovered and how they were found to be related to transition, and then how controlled oscillations were produced and studied in detail. The oscillations are shown to be the velocity variations accompanying a wave motion in the boundary layer, this wave motion having all of the characteristics predicted by a stability theory based on the exponential growth of small disturbances. A review of this theory is given. The work is thus experimental confirmation of a mathematical theory of stability which had been in the process of development for a period of approximately 40 years, mainly by German investigators. 42 p. 20c.

RP1773. Ceramic coatings for high-temperature protection of steel.

William N. Harrison, Dwight G. Moore, and Joseph C. Richmond

A new type of ceramic coating for the protection of low-carbon steel in high-temperature service was developed during the war at the National Bureau of Standards and was used by the Army and Navy on the exhaust systems of certain aircraft and other vehicles. The outstanding features of these coatings are (a) high resistance to chipping under repeated thermal shock, (b) protection of the metal against oxidation during prolonged exposure at temperatures up to about 1,250°F, (c) freedom from the cracking and blistering produced in conventional porcelain enamels under comparable conditions of high temperature and severe thermal gradients, and (d) a mat surface which does not show high lights and, therefore, decreases the visibility. 15 p. 10c.

RP1774. Electrical characteristics of quartz-crystal units and their measurement.

William D. George, Myron C. Selby, and Reuben Scolnik

The problem of measuring the dynamic electrical characteristics of high frequency quartz-crystal units was investigated by using ordinary laboratory instruments such as  $r$ - $f$  bridges and  $Q$  meters. Measurement methods and technics are given, together with relative merits and limitations. Antiresonance impedance up to 5,000,000 ohms was measured to  $\pm 5$  percent or better. Data concerning constancy of electrical characteristics, secondary responses, and changes with amplitude of vibration and temperature are given for a large number of 8.7 Mc BT-cut crystal units having representative types of mountings. Results obtained on a few 50- and 100-kc units are also included. A convenient type of graphical representation of electrical characteristics of normal crystal units is suggested. 20 p. 15c.

RP1775. Ionization and dissociation of *cis*- and *trans*-2-butene by electron impact.

Vernon H. Dibeler

A study has been made of the appearance potentials and relative abundance of a number of ions from the mass spectra of *cis*- and *trans*-2-butene. The appearance potentials were found to be in generally good agreement with spectroscopic data. The mass spectra of the 2-butenes were compared with those of 1-butene and isobutene. The  $C_2H_5^+$  ion was found to be the only ion showing a significant difference between the 2-butene isomers. This difference approached a maximum with ionizing electrons of 40-volt energy and remained constant up to energies of 100 volts. 8 p. 10c.

RP1776. Properties of barium-strontium titanate dielectrics.

Elmer N. Bunting, George R. Shelton, and Ansel S. Creamer

The results on barium-strontium titanates are given for heat treatments, absorption, shrinkage, thermal expansion, dielectric constant ( $K$ ) at  $-60^\circ$  to  $85^\circ\text{C}$ , and also for  $Q$ , the reciprocal of the power factor, at  $25^\circ\text{C}$  for frequencies of 50 to 20,000 kc/s. A few measurements of  $K$  and  $Q$  were made at 3,000 mc/s. Specimens matured (absorption less than 0.1 percent) at  $1,250^\circ$  to  $1,430^\circ\text{C}$ .  $K$  values ranged from 34, for  $\text{BaO}:\text{4TiO}_2$ , to several thousand for specimens with compositions on the  $\text{BaTiO}_3$ - $\text{SrTiO}_3$  join. Specimens having the composition  $\text{BaO}:\text{5TiO}_2$  were unique in that their temperature coefficient of  $K$  was practically zero.  $Q$  values ranged from 50 to 100 for test pieces containing over 40 percent of BaO, and from 400 to 10,000 for those with less than 40 percent of BaO.  $K$  values did not change appreciably with frequency.

Linear thermal expansions between 25° and 700°C ranged from 0.6 to 0.84 percent. Many of these specimens could be used in radio equipment. 13 p. 10c.

RP1777. Determination of small amounts of carbon monoxide in air by various reference methods.....Martin Shepherd

This is a report of the cooperative analyses of two samples of carbon monoxide in air. The analyses were made by laboratories engaged in investigations for the military services during the past war, and this work served to bring the results of these laboratories into common agreement. 8 p. 10c.

RP1778. A magnetic-lens electron spectrometer: Radiations from 5.3 year cobalt<sup>60</sup>. Leonard C. Miller and Leon F. Curtiss

An improved magnetic-lens spectrometer, similar in principle to that described by Deutsch, Elliott, and Evans has been constructed. The structure, operation, and method of calibration, using a ThB + C deposit, is described. Results of measurements of the primary beta-ray spectrum and of the gamma-ray spectrum converted in a uranium radiator are given. These give an end point for the value reported by Deutsch, Elliott, and Roberts of  $0.308 \pm 00.008$  million electron volt (Mev). Two gamma rays were measured at 1.16 and 1.32 Mev, likewise in agreement with the values of  $1.100 \pm 0.03$  and  $1.30 \pm 0.03$  Mev, given by the same authors. 6 p. 10c.

RP1779. Preparation and physical properties of several aliphatic hydrocarbons and intermediates.

Frank L. Howard, Thomas W. Mears, A. Fookson, Philip Pomerantz, and Donald B. Brooks

In the course of a continuing investigation of the knock ratings of aliphatic hydrocarbons, pure paraffins and olefins have been prepared in quantities sufficient for engine tests. This report describes the methods of preparation and purification of three pentanes, four hexanes, three heptanes, four octanes, eight nonanes, seven decanes, four hexenes, five octenes, six nonenes, six decenes, and a number of alcohols, ketones, esters, and alkyl halides. Most of these compounds were highly purified. Physical constants measured include freezing point, boiling point, and its variation with pressure, refractive index, and density, and their variations with temperature. 31 p. 15c.

RP1780. Synchronization of oscillators.....Robert D. Huntoon and Albert Weiss

A theory is presented which predicts the behavior of any self-limiting oscillator in the presence of an injected sinusoidal voltage or current of small but constant magnitude. The internal mechanism responsible for synchronization is not needed, and the theory is thus applicable to any source of alternating current. Experimental verification of the theory is presented for the case of a low-power Hartley oscillator operating at 11.5 megacycles.

The theory is extended to include the mutual synchronization of two oscillators of arbitrary properties, and a method of treating the mutual interaction of several oscillators is outlined.

The theory is applied to a number of examples to indicate briefly the properties of a synchronized oscillator when used as (1) a linear voltmeter for small voltages, (2) a field-intensity meter, (3) a linear amplitude modulation demodulator for small signals, (4) a frequency modulation demodulator, (5) a synchronous amplifier limiter. The use of a synchronized oscillator for these applications is of particular interest because microwave generators can be used in addition to the more conventional triode oscillators. 14 p. 10c.

RP1781. Disintegration of scandium<sup>46</sup>.....Irving Feister and Leon F. Curtiss

The beta and gamma radiations of scandium<sup>46</sup> have been studied by means of a magnetic-lens spectrometer. The beta-ray spectrum was found to be simple, with the maximum energy at 0.36 Mev. No indications were found of any other group of beta rays having energies above this value. The gamma-ray spectrum consists of two gamma rays, with energies 0.88 Mev and 1.12 Mev. These two gamma lines appear to be of equal intensity, and are therefore very probably in cascade. 4 p. 10c.

RP1782. High-temperature X-ray diffraction apparatus.

Alvin Van Valkenburg and Howard F. McMurdie

A furnace for obtaining X-ray powder diffraction patterns of samples at elevated temperatures has been designed and constructed. This furnace is used with the Norelco X-ray spectrometer, in which the photographic film is replaced by a Geiger counter. The assembly has the following advantages over previously described high-temperature X-ray powder diffraction cameras: (1) Any number of patterns can be obtained without intermediate cooling of the sample, (2) in 40 minutes the pattern



is produced in a form ready for study, and (3) patterns can be obtained at temperatures up to 1,500°C. The diffraction data for the form of  $2\text{CaO} \cdot \text{SiO}_2$  are given. 4 p. 10c.

RP1783. Heats of combustion and isomerization of six nonanes.

Walter H. Johnson, Edward J. Prosen, and Frederick D. Rossini

The heats of isomerization of six of the nonanes were determined by measurement of the ratios of the heats of combustion in the liquid state of purified samples of these compounds by the procedure previously described for other hydrocarbons. The data yield the following values for the heat of isomerization in the liquid state at 25°C,  $\Delta H^\circ$ , of *n*-nonane into the other nonanes, in kilocalories per mole: *n*-nonane, 0.00; 3,3-diethylpentane,  $-0.01 \pm 0.33$ ; 2,2,3,3-tetramethylpentane,  $-0.70 \pm 0.31$ ; 2,2,3,4-tetramethylpentane,  $0.56 \pm 0.22$ ; 2,2,4,4-tetramethylpentane,  $-1.11 \pm 0.25$ ; 2,3,3,4-tetramethylpentane,  $-0.62 \pm 0.35$ . These data were combined with the value previously reported for the heat of combustion of *n*-nonane to obtain values for the heats of combustion of the other five nonanes in the liquid state at 25°C. 4 p. 10c.

RP1784. Structure of difructose anhydride II.

Emma J. McDonald and Anne L. Turcotte

The structure of difructose anhydride II is shown to be 2,1'-4,2'-difructofuranose. 3,4,6-Trimethylfructose has been identified as one of the hydrolysis products of hexamethyl difructose anhydride II. This has been accomplished by a chromatographic separation with subsequent identification of 3,4,6-trimethylglucosazone. 3 p. 10c.

RP1785. Mangabeira latex and rubber. .Norman Bekkedahl and Waldemar Saffiot

The tree *Hancornia speciosa*, more commonly known as the mangabeira, which grows in several of the tropical states of Brazil, yields a rubber-containing latex. This tree is very well known for the delicious fruit (mangaba) it bears, but it does not have such a good reputation for the quality of rubber it produces. The natives of Brazil coagulate this rubber by means of solutions of alum or sodium chloride. It has been found, however, from this investigation that if these coagulating agents are replaced by dilute hydrochloric acid or by the latex from another tree, the caxinguba (*Ficus anthelmintica*), a rubber of much improved properties can be produced. 12 p. 10c.

RP1786. Spectrographic determination of minor elements in portland cement.

Armin W. Helz and Bourdon F. Scribner

A rapid spectrographic procedure for the determination of the minor metallic elements in portland cement is described. The method shows promise of easy extension to cement raw materials and many ceramic materials, provided reliable standard samples of these materials are available.

In the application of the method to portland cement, seven minor elements were determined. The precision in terms of probable error of a single determination is within 3 percent of the oxide concentration for aluminum, iron, magnesium, manganese, and titanium; 5 percent of the  $\text{Na}_2\text{O}$  concentration; and 8 percent of the  $\text{K}_2\text{O}$  concentration. Other minor elements, such as lithium, strontium, chromium, zirconium, and vanadium, may readily be included.

The spectrographic analyses of 21 portland cements are compared with chemical results for an estimate of the accuracy. Salient features of the procedure are (1) employing pellets consisting of the cement powder, with graphite as a binder, cobalt oxide as an internal standard, and potassium nitrate as a buffer, (2) applying the pellet as an electrode for excitation by an overdamped condenser discharge, and (3) photographing the spectrum with a step sector and a diffusing screen for obtaining uniformity of illumination. 9 p. 10c.

RP1787. Electrical methods for diamond-die production.

Chauncey G. Peters, Walter B. Emerson, Karl E. Nefflen, Forest K. Harris, and Irvin L. Cooter

Electrical methods to drill diamond have been developed and applied to the making of diamond wire-drawing dies 0.0005 to 0.0015 of an inch in diameter that heretofore were produced solely by mechanical operations. The time required to produce excellent dies is reduced materially by applying these electrical methods to the following operations: 1, Pilot drilling the primary cone with a high-voltage spark in air; 2, drilling the secondary cone with a low-voltage spark in an electrolyte.

These two methods of drilling are described and their application to the making of small dies at the National Bureau of Standards is given in detail. 16 p. 10c.

RP1788. Effect of artificial aging on tensile properties and resistance to corrosion of 24S-T aluminum alloy.

Hugh L. Logan, Harold Hessing, and Harold E. Francis

The effect of aging commercial 24S-T aluminum alloy sheet, for various periods at 350°, 375°, 385° and 400°F, on its tensile properties and resistance to corrosion was determined. Aging for 3 hours at 385°F produced an increase in yield strength of about 25 percent above an initial value of about 50,000 lb/in.<sup>2</sup>, an increase in tensile strength of about 3 percent above an initial value of 70,000 lb/in.<sup>2</sup>, and a decrease to about one-third of the initial elongation of 17 to 18 percent. Approximately the same values for these properties were obtained by aging the material for 20 hours at 350°F, 5 hours at 375°F, or 1½ hours at 400°F. Materials aged 3 to 10 hours at 385°F and 6 to 12 hours at 375°F were generally immune to stress corrosion cracking and were no more severely damaged in corrosive media, NaCl + H<sub>2</sub>O<sub>2</sub> solution or marine atmosphere, than the commercially heat-treated material exposed without artificial aging. 25 p. 15c.

RP1789. Cooperative analysis of a standard sample of natural gas with the mass spectrometer.....Martin Shepherd

The mass spectrometer was used for the analysis of a standard sample of natural gas by laboratories cooperating with Subcommittee VII of Committee D-3 of the American Society for Testing Materials. The results of the cooperative analysis show the reproducibility and, in certain respects, the accuracy of this powerful new apparatus for gas analysis. The heating value and the specific gravity of the sample calculated from the analytical data were compared with the known values. 7 p. 10c.

RP1790. Infrared emission spectra of krypton and argon.

Curtis J. Humphreys and Earle K. Plyler

The analysis of the spectra of the noble atmospheric gases, utilizing descriptive data covering the photographically accessible region, has long indicated the possibility of a considerable extension of most of these spectra into the infrared region beyond 1.3 microns. Observations of the spectra of krypton and argon, in the region between 1 and 2 microns, have been made with a Perkin-Elmer spectrometer, fitted with a flint-glass prism cut to an angle of 55 degrees. The sources were Geissler tubes, used in previously reported work.

More than 15 new lines of krypton have been observed. Part of these are blends of unresolved pairs or groups. The emission maxima have been determined in favorable cases to a precision of two wave numbers, roughly equivalent to one-tenth of the smallest scale division on the wavelength drum. All observed lines have been classified, the most intense being represented by combinations of the type  $2p-3d$ , according to Paschen's notation. Two new levels from the configuration  $s^2p^2f$  have been found. The remaining unobserved combinations of the type  $1s-2p$ , occurring in this region, are, with one exception, too weak to be observed. The argon infrared spectrum was observed by Paschen. More of its predicted combinations are in the photographic region than in the case of krypton. A few lines near 1.4 microns have been observed. 5 p. 10c.

RP1791. Dipole moments and resonance of some benzein indicators and related compounds.....Arthur A. Maryott and S. F. Acree

An apparatus for the measurement of dielectric constants of liquids by the heterodyne method and, in particular, for the determination of dipole moments is described. Dipole moments ( $\times 10^{18}$  electrostatic unit (esu)) are reported for, 4-hydroxybenzophenone (3.96), 4,4'-dihydroxybenzophenone (4.49), 4-hydroxy-2-methyl-5-isopropylbenzophenone (3.59), fuchson (5.83), benzaurin (6.85), aurin (7.96), *o*-cresolbenzein (6.68), thymolbenzein (6.67) and  $\alpha$ -naphtholbenzein (6.07) using dioxane as solvent. The last six compounds contain the quinoidal structure and have unusually large moments. The values are nearly double those found for the derivatives of benzophenone that have corresponding polar groups. The influence of resonance involving highly dipolar excited structures in determining the actual state of these molecules is discussed. 8 p. 10c.

RP1792. An improved Geiger-counter arrangement for determination of radium content.....Francis J. Davis

Geiger-counter apparatus in which several counters may be placed in any position relative to each other is described. A circular arrangement of counters to give a counting rate approximately independent of the position of a source near the center of the circle is discussed. The relation of the position of the source to the counting rate of a single Geiger counter is discussed. A method of calculation of the self-absorption of a sample for the Geiger-counter arrangement used is given. 6 p. 10c.



RP1793. Changes caused in the refractivity and density of glass by annealing.

Arthur Q. Tool, Leroy W. Tilton, and James B. Saunders

The changes in the refractivity of several glasses caused by annealing at different temperatures are presented. The results are given in the form of equilibrium temperature coefficients, as the glasses were annealed at each annealing temperature until there was no further change in the refractivity or density. The measurements on refractivity and density were made at standard atmospheric temperatures since the changes in these properties at such temperatures have a greater practical significance than the corresponding changes at temperatures within the annealing range. 7 p. 10c.

RP1794. Conductimetric titrations of acids and bases in benzene and dioxane.

Arthur A. Maryott

Acid-base titrations were made conductimetrically in pure benzene and dioxane with picric, trichloroacetic, and camphorsulfonic acids, together with primary, secondary, and tertiary amines. Although the conductances of the solutions were extremely low, lower by a factor of  $10^{-3}$  or more than in water, the titrations gave sharp end points which generally were accurate to 1 percent or better. The unusual, though similar behavior of all titrations involving trichloroacetic or camphorsulfonic acid, where the conductance of the salt was enhanced greatly by the presence of free acid, was interpreted in terms of a reaction between salt and acid leading to the formation of a complex anion. The occasional variations in conductance with time, in one instance suggesting slow attainment of some secondary ionic equilibrium, and the effect upon the titration curves of the addition of a small amount of methyl alcohol to the solvent are discussed. 10 p. 10c.

RP1795. Analyses of alkylates and hydrocodimers.

Augustus R. Glasgow, Jr., Anton J. Streiff, Charles B. Willingham, and Frederick D. Rossini

This paper presents the results of work by the American Petroleum Institute Research Project 6 on the analyses, with respect to individual hydrocarbon components, of 28 different alkylates and hydrocodimers. The samples reported include 15 sulfuric-acid alkylates (one  $C_3$ , six  $C_4$ , one  $C_4-C_5$ , four  $C_6$ , one hot-acid dimer, one hot-acid trimer, and one cold-acid trimer), five hydrofluoric-acid alkylates (one  $C_3$ , one  $C_3-C_4$ , one  $C_4$ , one  $C_4-C_5$ , and one  $C_6$ ), and 8 hydrocodimers. The analyses were made utilizing analytical distillations performed at high efficiency with high reflux ratio, together with accurately measured values of boiling point (obtained during the distillation) and of refractive index of the fractions of distillate.

Also included in this report is a summary of the results of the subsequent spectrographic analyses, with respect to individual components, of one of the  $C_4$  alkylates by six different laboratories, involving one Raman, one mass, and four infrared spectrometers. 45 p. 25c.

RP1796. An improved ice calorimeter — the determination of its calibration factor and the density of ice at  $0^\circ C$ . Defoe C. Ginnings and Robert J. Corruccini

There has been described an improved Bunsen ice calorimeter which has been constructed for measurements of enthalpy at high temperatures by the "drop" method. The calibration factor of the ice calorimeter has been determined electrically to be  $270.37 \pm 0.06$  int. joules per gram of mercury, equivalent to  $64.631 \pm 0.014$  calories per gram of mercury, where 1 calorie = 4.1833 int. joule. Using this calibration factor, it is calculated that the density of ice at  $0^\circ C$  and 1 atmosphere pressure is  $0.91671 \pm 0.00005$  g/ml. 10 p. 10c.

RP1797. Enthalpy, specific heat, and entropy of aluminum oxide from  $0^\circ$  to  $900^\circ C$ . Defoe C. Ginnings and Robert J. Corruccini

Apparatus consisting of a furnace and ice calorimeter has been used for the measurement of enthalpies at high temperatures by the "drop" method. The enthalpy (referred to  $0^\circ C$ ) of a sample of aluminum oxide (corundum) has been determined in the range  $0^\circ$  to  $900^\circ C$ . Derived values of specific heat and entropy are given. 8 p. 10c.

RP1798. Transmission measurements with the Beckman quartz spectrophotometer. Kasson S. Gibson and Margaret M. Balcom

The Beckman quartz photoelectric spectrophotometer, covering the wavelength range from about 200 to 1,200 millimicrons is proving of great utility in spectral transmission and absorption measurements. Essential features of the instrument are described, including a constant-temperature inclosure (for samples) designed and constructed at the Bureau. Various instrumental characteristics are noted and possible errors discussed, particularly those that may be present in the measurement of polarizing samples. Wavelength calibrations are shown for two instruments. A detailed over-

all check of the reliability of data obtained on the Beckman spectrophotometer by means of glass standards of spectral transmittance shows it to give results over the wavelength range from 390 to 750  $m\mu$  fully as reliable as those obtained with our other spectrophotometers, if various precautions are taken. 16 p. 10c.

RP1799. Mass spectrometer study of rare gases.

Vernon H. Dibeler, Fred L. Mohler, and Robert M. Reese

Appearance potentials and isotope abundance ratios for the rare gases have been measured with a Consolidated mass spectrometer. Results are consistent with spectroscopic values of appearance potentials and published isotope ratios. Ion currents at unit pressure increase with atomic number but no simple relation is evident. 4 p. 5c.

RP1800. Hydrocarbons in the 102° to 108°C fraction of petroleum.

Augustus R. Glasgow, Jr., Charles B. Willingham, and Frederick D. Rossini

This report describes the analysis of the hydrocarbons in the 102° to 108°C aromatic-free fraction of petroleum, which is shown to be composed substantially entirely of the following three compounds (normally boiling at the temperature indicated): ethylcyclopentane at 103.5°C; 1,1,3-trimethylcyclopentane at 104.9°C; 2,2-dimethylhexane at 106.8°C. The amounts of these three compounds in the original Ponca, Oklahoma, crude petroleum are estimated to be 0.16, 0.30, and 0.01 percent, respectively by volume. 6 p. 10c.

RP1801. Heats of combustion and solution of liquid styrene and solid polystyrene, and the heat of polymerization of styrene.

Donald E. Roberts, William W. Walton, and Ralph S. Jessup

Bomb-calorimetric measurements have yielded for the heats of combustion ( $-\Delta H_c^\circ$ ) at 25°C of liquid styrene and solid polystyrene to form gaseous carbon dioxide and liquid water, the values  $4394.88 \pm 0.67$  int. kj/mole ( $1050.58 \pm 0.14$  kcal/mole) and  $4325.09 \pm 0.42$  int. kj/ $C_8H_8$ -unit ( $1033.89 \pm 0.10$  kcal/ $C_8H_8$ -unit), respectively, and for the heat of polymerization of liquid styrene to solid polystyrene at 25°C, the value  $69.79 \pm 0.66$  int kj/mole ( $16.68 \pm 0.16$  kcal/mole). The results obtained on two samples of polystyrene of different molecular weight were in agreement within the precision of the measurements.

Measurements of the heat of solution of solid polystyrene in liquid monomeric styrene gave the value  $3.59 \pm 0.21$  int. kj ( $0.86 \pm 0.05$  kcal) evolved per  $C_8H_8$ -unit of polystyrene at 25°C. Addition of this to the value for the heat of polymerization of liquid styrene to solid polystyrene gives the value  $73.38 \pm 0.69$  int. kj ( $17.54 \pm 0.16$  kcal) per mole of styrene for the heat of polymerization of liquid styrene at 25°C, when the final product is a solution of polystyrene in styrene containing 6.9 percent by weight of polystyrene. 10 p. 10c

RP1802. Torsion of a rubber cylinder.....R. S. Rivlin

It has been predicted theoretically that, in general, a right-circular cylinder of incompressible, highly elastic material, which is isotropic in its undeformed state, cannot be held in a state of pure torsional deformation by means of a torsional couple alone. In addition, normal surface tractions must be exerted over the plane ends of the cylinder. These normal surface tractions depend on the amount of torsion and on position on the plane ends of the cylinder. Experiments are reported here in which this phenomenon is observed in a right-circular cylinder of pure gum compound and the dependence of the surface traction on amount of torsion and its distribution over the surface of the cylinder is studied. 16 p. 10c.

RP1803. Compensation of the aperture ratio markings of a photographic lens for absorption, reflection, and vignetting losses.....Irvine C. Gardner

At present the diaphragm markings of a photographic lens are based entirely upon geometrical considerations and do not take into account the losses of light resulting from absorption, reflection, and scattering. A method of equivalent marking is described, in which, for example, the marking 8 does not correspond to the geometrically determined aperture ratio 1:8 but to an opening sufficiently larger to permit the transmission of as much light as would be transmitted by the aperture 1:8 in the absence of any losses due to absorption, etc. Such a system of apertures may be referred to as equivalent, or compensated, apertures. Two systems of compensation are given, one based upon the illumination at the center of the field and the other based upon the average illumination over the entire field, thus taking vignetting into account. A relatively simple photometric procedure for determining either of the two systems of compensated graduations is described. For use during a transition period, a system of markings is described that will permit exposures to be determined either with light losses compensated or by the present method without compensation. Except for the



change of markings on a lens, no other instrumental changes are required to apply the new system of exposure determination. 8 p. 10c.

RP1804. Heat capacities of gaseous oxygen, isobutane, and 1-butene from  $-30^{\circ}$  to  $+90^{\circ}\text{C}$ .....Paul F. Wacker, Ruth K. Cheney, and Russell B. Scott

An adiabatic constant-flow calorimeter previously used was modified to improve its accuracy. The heat capacity of gaseous oxygen was measured at  $-30^{\circ}$ ,  $+40^{\circ}$ , and  $+90^{\circ}\text{C}$ , and the results were compared with values calculated from spectroscopic data. The experimental and spectroscopic values agreed within 0.04, 0.02, and 0.11 percent at the three temperatures. The heat capacity of isobutane was measured at  $-30^{\circ}$ ,  $+0^{\circ}$ ,  $+40^{\circ}$ , and  $+80^{\circ}\text{C}$ . A few measurements were made on 1-butene at  $40^{\circ}$  and  $90^{\circ}\text{C}$ . Measurements on the hydrocarbons at two or more pressures permitted the calculation of values of  $(\alpha^2 V / \alpha T^2)_P$ . 10 p. 10c.

RP1805. Heats of solution of solid solutions of hexacalcium dialumino ferrite and dicalcium ferrite.....Edwin S. Newman

The heats of solution of members of the series of solid solutions between  $6\text{CaO} \cdot 2\text{Al}_2\text{O}_3 \cdot \text{Fe}_2\text{O}_3$  and  $2\text{CaO} \cdot \text{Fe}_2\text{O}_3$  have been determined. Members of this solid-solution series are formed in cement clinker instead of the single compound  $4\text{CaO} \cdot \text{Fe}_2\text{O}_3 \cdot \text{Al}_2\text{O}_3$  as formerly assumed. It has been shown that this assumption causes a negligible error in the latent heats at present used in estimating the glass content of portland cement clinker. It is pointed out, however, that the compositions and heats of solution of the glasses actually formed in portland cement clinker are still unknown. These quantities must be determined before the accurate estimation of the phase composition and glass content of commercial portland cement clinker is possible. 4 p. 5c.

RP1806. Relative thickness of lead, concrete, and steel required for protection against narrow beams of X-rays.

George Singer, Harold O. Wyckoff, and Frank H. Day

The lead equivalents of X-ray protective barriers are given for both concrete and steel for potentials between 200 and 1,400 kv. These were determined experimentally using a pressure ionization chamber and an X-ray tube to which constant potential was applied. Narrow X-ray beams were used. The data obtained are compared with those published by other workers. Data on the relative masses referred to lead of both concrete and steel barriers are included. The agreement among the several laboratories is satisfactory when consideration is given to differences in the test specimens used and in the experimental technique. 7 p. 10c.

Title page and contents for volume 38. 5c.

## CIRCULARS

Circulars are compilations of information on various subjects related to the Bureau's scientific, technical, and engineering activities. They include not only the results of Bureau studies, but give data of general interest from other sources.

This series also contains Recommended Specifications, United States Government Specifications, and United States Government Master Specifications formerly issued by the Bureau. These bear a Specification number in addition to the Bureau Circular number, but all of these specifications have been canceled or superseded by Federal Specifications, now formulated by the Federal Specifications Board. The current list of Federal Specifications giving titles, symbols, and prices entitled "Federal Specifications Index", revised to January 1, 1947, is for sale by the Superintendent of Documents, Government Printing Office, Washington 25, D. C., price 35 cents. A simplified list (Price List 75) is available free from the Superintendent of Documents.

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- C125. United States Government specification for soap powder. 1922.
- C126. United States Government specification for salt water soap. 1922.
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- C429. Photoelectric tristimulus colorimetry with three filters. Richard S. Hunter. 1942. 15c.

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 C435. American standard specification for dry cells and batteries. 1942. (Supersedes C414. Superseded by C466).  
 C436. Low-cost glazes for structural clay products. Ray T. Stull and Paul V. Johnson. 1942. 10c.  
 C437. Optical and mechanical characteristics of 16-millimeter motion-picture projectors. Robert E. Stephens. 1942. 10c.  
 C438. Static electricity.....Francis B. Silsbee

The nature and origin of the charges of static electricity arising in industrial processes are discussed, and various methods of mitigation of the hazards which they introduce are suggested. By defining suitable units for the quantities involved and stating quantitative relationships between them, a basis is given for an engineering treatment of the phenomena. June 10, 1942. 36 p. 10c.

- C439. Acoustic performance of 16-millimeter sound motion-picture projectors. Wilbert F. Snyder

This Circular presents information to assist the prospective purchaser of a motion-picture projector in the preparation of a specification and in the selection of equipment capable of good performance, yet not excessive in cost. Objective test methods are described in detail, and simplified methods of sound measurements are indicated. Although over-all performance of the equipment is stressed, certain difficulties and lack of suitable test film prevent direct measurement of some of these characteristics. Measurements on representative equipment are included. Improvements in 16-mm sound projectors are suggested. July 6, 1942. 56 p. 15c.

- C440. Polarimetry, saccharimetry, and the sugars.

This Circular supersedes National Bureau of Standards Circular No. 12, issued July 6, 1906, and Circular No. 44, issued January 15, 1914, and revised November 1, 1917. The main purpose of this treatise is to explain the application and manipulation of polarized light for industrial, analytical, and theoretical purposes. May 1, 1942. 810 p. \$2.75 (bound in blue buckram).

- C441. Elevator wire rope maintenance.

Executive Committee for the American Standard Safety Code for Elevators, Dumbwaiters, and Escalators

This service bulletin covers the items affecting rope life, which include lack of lubrication, unequal tensions, misalignment of sheaves, lack of maintenance of sheave grooving, poor brake setting, unduly high peaks of acceleration and retardation, and changes in top and bottom hoistway clearances. It discusses methods of checking and correcting these particular items, and closes with a suggestion that rope life be extended further by decreasing elevator service, either by running fewer cars or by establishing skip stops, or by similar methods. Dec. 7, 1942. 7 p. 5c.

- C442. Maintenance of elevator mechanical safety appliances.

Executive Committee for the American Standard Safety Code for Elevators, Dumbwaiters, and Escalators

This Circular covers the items affecting the proper operation of governors, safeties, and buffers. Governor items include clearances, driving-sheave wear, sluggish action, and condition of jaws and of governor rope. The functional requirements of the releasing carrier are discussed in detail. This is followed by a general paragraph on the function of undercar safeties. There are also paragraphs on cleaning and maintenance of safeties and a discussion of various commonly used types of safety equipment. These include instantaneous, flexible guide-clamp, wedge-clamp, and spring-actuated safeties. The need for periodic tests is stressed.

Section III discusses various requirements for guide rails, the need for adequate rail fastenings, the effect of building settlement, maintenance of rail surface, and inspection of rails after the setting of the safety.

Section IV, on buffers, covers the proper grade of oil for oil buffers, importance of maintaining oil level, correct alinement of buffers, anchorage of buffer cases, corrosion of metallic parts, and flooding.

A paragraph is devoted to the checking of alinement and supports of spring buffers. Jan. 9, 1943. 10 p. 5c.



C443. Maintenance of elevator hoistway and car enclosures and equipment.  
Executive Committee for the American Standard Safety Code for Elevators,  
Dumbwaiters, and Escalators

This Circular includes a brief discussion of elevator accidents, stressing the large percentage occurring at hoistway entrances, and then discusses in some detail the protective devices for hoistway doors and the methods of maintaining such devices in the best operating condition. Instructions on the care of floors at elevator entrances are given, and the need for maintaining threshold illumination is stressed. The value of paint or other protective coatings on machine-room and hoistway walls is brought out. March 8, 1943. 8 p. 5c.

C444. Maintenance of elevator hoisting machines and brakes.  
Executive Committee for the American Standard Safety Code for Elevators,  
Dumbwaiters, and Escalators

This Circular covers certain suggestions for the inspection and checking of elevator hoisting equipment, including motors, gearing, brakes, and driving sheaves and drums. The inspection of belted machines is covered briefly, and there is a paragraph devoted to overhead sheaves and bearings. Motor-generator sets are covered by cross reference to similar equipment used in hoisting machines. March 15, 1943. 6 p. 5c.

C445. Effect of humidity on physical properties of paper. . . . . Frederick T. Carson

To make available data that have been out of print for some time, an old publication by the National Bureau of Standards has been revised and the essential data presented again. The data are included in seven tables and six graphs. They show the variation with humidity of basic ream weight, bursting strength, tearing resistance, folding endurance, tensile strength, and stretch. References to the literature are included to supplement the information. Jan. 31, 1944. 12 p. 5c.

C446. Dead-weight machines of 111,000- and 10,100-pound capacities.  
Bruce L. Wilson, Douglas R. Tate, and George Borkowski

A dead-weight testing machine of 102,000-lb capacity was installed at the National Bureau of Standards in 1927 to provide means for calibrating elastic calibration devices, which are used to calibrate force-indicating testing machines. To obtain a larger number of test loads the original machine was altered by the addition of nine 1,000-lb weights and an operating mechanism. To obtain the smaller test loads necessary for the calibration of elastic calibration devices having smaller capacities, a new machine of 10,000-lb capacity was installed. The two machines are described, and the errors of the weights of the machines are discussed. June 1943. 14 p. 5c.

C447. Mechanical properties of metals and alloys.  
John L. Everhart, W. Earl Lindlieff, James Kanegis, Pearl G. Weissler, and  
Frieda Siegel

This Circular is a summary of the results of a comprehensive survey of the technical literature on the strength and related properties, thermal expansion, and thermal and electrical conductivities of ferrous and nonferrous metals and alloys at normal, high, and low temperatures. In general, the data are presented in tabular form, although graphical representation is often used to indicate the effects of changing composition or conditions on the properties. Data on aluminum, copper, iron and steel, lead, magnesium, nickel, tin, zinc, a number of miscellaneous metals, and their alloys are included. The Circular is not limited to conventional engineering materials but contains the data on properties of many materials not usually classed as such. Literature references to the sources of the data are included. Dec. 1, 1943. 481 p. \$2.25 (buckram bound).

C448. Permanent magnets. . . . . Raymond L. Sanford

This Circular gives general information regarding the composition, treatment, and properties of permanent-magnet materials and the design and testing of permanent magnets. Aug. 10, 1944. 39 pp. 10c.

C449. Hydrometer correction tables and thermal density coefficients for vegetable tanning extracts. . . . . M. G. Blair and E. L. Peffer

Tables are presented for correcting hydrometer readings made in vegetable tanning extracts at observed temperature in degrees barkometer, in degrees Twaddle, and in degrees Baumé to readings at the standard temperature 60°F. Thermal density coefficients are also included, which make possible the calculation of the density of a tanning extract at any temperature within the range of the investigation if its specific gravity at 60°/60°F is known. These tables are based on an investigation carried out by the National Bureau of Standards on the density and thermal expansion of

several vegetable tanning extracts — quebracho, oak bark, hemlock bark, chestnut, and mangrove bark extracts. The range is from 1.00 to 1.12 specific gravity at 60°/60°F and from 50° to 100°F. May 4, 1945. 24 p. 10c.

C450. Underground corrosion.....Kirk H. Logan

This circular is a summary of the results of the National Bureau of Standards investigations of underground corrosion which began in 1922. Relations between the physical and chemical properties of the soil and their corrosiveness are described. The results of field tests of commonly used ferrous materials, ferrous alloys, lead, copper, copper alloys, zinc, asbestos-cement and a number of metallic and non-metallic coatings are given. Results of extensive field tests on bituminous pipe coatings made with the cooperation of the American Gas Association and American Petroleum Institute are also given. Methods of testing soils and coatings are described and their usefulness discussed. The theory and application of cathodic protection to underground structures are described. Details of test methods and apparatus are given in six appendices. Nov. 27, 1945. 312 p. \$1.25. (buckram bound).

C451. Factors affecting results obtained with the Mooney Viscometer.

Rolla H. Taylor

Experience with the operation of the Mooney Viscometer in 18 laboratories indicates the need for better reproducibility of results. A study of the available data from these laboratories along with numerous experiments made at the National Bureau of Standards have shown the factors that must be considered in improving the reproducibility. If uniformity in the values of Mooney viscosity on the same sample with different viscometers and in different laboratories is to be obtained, the methods of adjustment that must be followed and the precautions that must be taken are cleaning, mechanical calibration, dimensions of dies, die holders, and rotors, die closures, and preparation of test pieces. Each of these items are the errors which may result from maladjustments and lack of precautions in the use of this instrument are discussed. Nov. 8, 1945. 14 p. 5c.

C452. Slip casting of clay pots for the manufacture of optical glass at the National Bureau of Standards.

Raymond A. Heindl, Gordon B. Massengale, and Louis G. Cossette

Between 1918 and 1940 the Refractories Section of the National Bureau of Standards manufactured about 70 slip-cast clay pots annually for use by the Glass Section for the production of optical glass. From 1940 to 1945, to meet the increasing military requirements for optical glass, the pot production was expanded gradually to a maximum of 2,300 annually. This Circular describes the plant changes made, the new machinery and equipment installed, and the general manufacturing procedure used to bring about this increased production. A description is also given of the two types of pots produced, namely, one with a low-porosity lining for the manufacture of the more corrosive glasses, the other without the lining for the less corrosive glasses. Information is given on the control of the density of the pot in order to obtain low gas permeability of the pot wall and on many of the difficulties that had to be overcome in order to produce satisfactory pots. July 15, 1946. 19 p. 10c.

C453. Apparatus for determining water-vapor permeability of moisture barriers.

Frederick T. Carson and Vernon Worthington

A conditioning and testing cabinet is described in which the hygrometric conditions are maintained by equilibrium with a saturated solution of an appropriate salt. The temperature of this solution and of the testing chamber is held constant by means of an envelope of moving air that completely surrounds the testing chamber, an open-coil heater and a thermoregulator being used to control the temperature of this air bath. Devices for supporting and weighing the permeability cells in the cabinet, without disturbing the hygrometric conditions, are explained in detail. The cells, hung by hooks from a rotary suspension disk, can be suspended one at a time from a weighing rod attached to a balance. Interlocking mechanisms for selecting and picking up the cells facilitate the weighing and protect the apparatus and the permeability cells from accidental injury. A method and apparatus for mounting the specimens in the permeability cells are described also. Materials covering a large permeability range can be accommodated. Some suggestions are made for accelerating the testing of good moisture barriers. Nov. 8, 1946. 18 p. 10c.

C454. Proving rings for calibrating testing machines.

Bruce L. Wilson, Douglas R. Tate, and George Borkowski

A description is given of the proving ring, which was developed at the National Bureau of Standards to provide an accurate portable load-measuring device for calibrating testing machines. Methods are described for calibrating proving rings by



dead weights for loads up to 111,000 lb and by means of other calibrated proving rings for higher loads. Rings which complied with the specification included in the paper were subjected to tests to determine the errors introduced by variations of the conditions of use. Provided reasonable care is exercised in using proving rings, the errors are shown to be small compared to  $\pm 1$  percent, the generally recognized tolerance for testing machines. Aug. 14, 1946. 21 p. 10c.

C455. Flameproofing of textiles.....M. W. Sandholzer

This Circular includes a review of the history and principles of flameproofing; an outline of types of treatments and the more common processes, formulas, and testing methods; and a brief list of references on the general subject. A testing method is also outlined for indicating the relative hazard of untreated textiles and those rendered more flammable by processing or coating. Aug. 23, 1946. 20 p. 10c.

C456. Magnetic testing.....Raymond L. Sanford

This Circular gives general information regarding magnetic quantities, the magnetic characteristics of materials, the principles employed in magnetic testing apparatus, and a brief discussion of the theory and application of magnetic analysis. Nov. 6, 1946. 39 p. 10c.

C457. Weights per United States gallon and weights per cubic foot of sugar solutions.  
Carl F. Snyder and Lester D. Hammond

A table is presented showing the weights per United States gallon and weights per cubic foot of sugar (sucrose) solutions at 20°C. The table comprises the weights (metric and avoirdupois) per gallon in air; weights (avoirdupois) per cubic foot in air; true specific gravities 20°/20°C and 20°/40°C; apparent specific gravities; grams of sucrose per 100 ml of solution in vacuum; and degrees Baumé; all from 0° to 95° Brix. at intervals of 0.1° Brix. The calculations are based on the density values of Plato. The degrees Baumé are taken from the table of Bates and Bearce. A supplementary table is included, giving the weights per gallon in air at different temperatures.

This Circular is a revision of Circular C375 (1929); it also replaces Letter Circular LC770. Dec. 5, 1946. 28 p. 10c.

C458. Chemistry of collagen.....Joseph R. Kanagy

One of the most important industrial proteins is collagen. On treatment with tannins or certain inorganic salts, it is converted into leather. This process is known as tanning. By prolonged heating with water, collagen is changed into glue which has a large number of commercial applications, such as the making of paper, photographic plates and adhesives. This Circular gives a general outline of the physical and chemical properties of collagen and was prepared for the large number of chemists employed in industries where this material or its transition product, glue, is processed. May 29, 1946. 26 p. 10c.

C459. Announcement of changes in electrical and photometric units.

This Circular gives a short account of the development of new international agreements on practical units of electricity and of light. In pursuance of these agreements, the electrical units based upon the resistance of a column of mercury and the rate of deposition of silver in a voltameter will be superseded on January 1, 1948, by units derived from the fundamental mechanical units of length, mass, and time. This will increase the numerical values of resistances by 495 parts per million and those of voltages by 330 parts per million. The magnitude of photometric units will be fixed by assigning the value 60 candles per square centimeter for the brightness of a black-body radiator at the temperature of freezing platinum, and using certain standard spectral luminosity factors for the measurement of light differing in color from that of the black-body primary standard. This change in definitions of the units will involve little change in ratings of the common types of lamps. May 15, 1947. 7 p. 5c.

C460. Publications of the National Bureau of Standards, 1901 to June 30, 1947.

This Circular lists titles of the publications of the National Bureau of Standards from 1901 to June 30, 1947, with subject and author indexes.

For the period from January 1, 1942, to June 30, 1947, brief abstracts are included with the titles of the publications. 75c.

C461. Tables of selected values of properties of hydrocarbons.

Frederick D. Rossini, Kenneth S. Pitzer, William J. Taylor, John E. Kilpatrick, Joan P. Ebert, Charles W. Buckett, Mary G. Williams, Helene G. Werner

This book includes, in bound form, all the tables of properties of hydrocarbons (and certain closely related compounds) which have been issued as of May 31, 1947

by the American Petroleum Institute Research Project 44. Some explanatory remarks, and tables of fundamental constants, conversion factors, and molecular weights, are also included. \$2.75 (buckram bound).

C462. Ionospheric Radio Propagation.

This book presents the elementary principles of sky-wave radio propagation at high frequencies and their application to the problems of radio communication. The basic theory of electromagnetic wave propagation is given together with a detailed discussion of the structure of the ionosphere and the manner in which it reflects radio waves. Practical methods of calculating radio propagation conditions are given together with explanations of their derivation. In press.

C463. Safety for the household.....Stewart J. Owen

In this Circular consideration is given to the hazards (chemical, drugs and medicines, electrical, fire, gas, lightning, mechanical, gardening and yard tools, hand tools, home work-shop power tools, poisonous plants and vines often found in yards and gardens, etc.) and recommendations are made to eliminate those hazards or to cope with them where they cannot easily be eliminated. Methods of first aid are given including resuscitation, home treatment of burns, scalds, cuts and bruises. Information is given on the instruction of children in safe habits and of the value of organized community safety programs. Helpful suggestions are made for the building of a safe home and the installation in the home of approved equipment such as heating boilers, laundry and plumbing fixtures. Supersedes C397. 75c.



## HANDBOOKS

These are recommended codes of engineering and industrial practice, including safety codes, developed in cooperation with the national organizations and others concerned. In many cases the recommended requirements are given official status through their incorporation in local ordinances by State and municipal regulatory bodies.

- H1. Manual of inspection and information for weights and measures officials. 1918. (Supersedes M1. Superseded by H11).
- H2. National safety code for the protection of the heads and eyes of industrial workers. 1920. (Superseded by H24).
- H3. National electrical safety code. 1920. (Supersedes C54 to be superseded by H30).
- H4. Discussion of the national electrical safety code. 1920. (Supersedes C54).
- H5. American logging and sawmill safety code. 1923. 60c.
- H6. Safety rules for the installation and maintenance of electrical supply stations. 1926. (Superseded by H31).
- H7. Safety rules for the installation and maintenance of electric utilization equipment. 1926. (Superseded by H33).
- H8. Rules for the operation of electrical equipment and lines. 1926. (Superseded by H34).
- H9. Safety rules for radio installation. 1926. (Superseded by H35).
- H10. Safety rules for the installation and maintenance of electrical supply and communication lines. 1927. (Superseded by H32).
- H11. Weights and measures administration. 1927. (Supersedes H1. Superseded by H26).
- H12. (Formerly M92). Code for protection against lightning. 1929. (Superseded by H17).
- H13. (Formerly M95). Protection against lightning. 1929.
- H14. (Formerly M85). Specifications and tolerances for commercial weighing and measuring devices. 1929. (Superseded by H22).
- H15. X-ray protection. 1931. (Superseded by H20).
- H16. Wood poles for overhead electrical lines. 1931.
- H17. Code for protection against lightning. 1932. (Supersedes H12. Superseded by H21).
- H18. Radium protection for amounts up to 300 milligrams. 1934. (Superseded by H23).
- H19. Manual of fire-loss prevention of the Federal fire council. 1934. 2d ed., 1945, issued by Federal Works Agency. 30c.
- H20. X-ray protection. 1936. (Supersedes H15). 10c.
- H21. Code for protection against lightning. 1937. (Supersedes H12 and H17. Superseded by H40).
- H22. Specifications, tolerances, and regulations for commercial weights and measures and weighing and measuring devices. 1938. (Supersedes H14. Superseded by H29).
- H23. Radium protection. 1938. (Supersedes H18). 10c.
- H24. American Standard safety code for the protection of heads, eyes, and respiratory organs. 1938. (Supersedes H2). 20c.
- H25. Screw-thread standards for Federal services, 1939. (Superseded by H28).
- H26. Weights and measures administration. R. W. Smith. 1941. (Supersedes H11). 75c.
- H27. Safe handling of radioactive luminous compound. 1941. 10c.
- H28. Screw-thread standards for Federal services. 1942. (Supersedes H25. Superseded by H28, 1944).
- H31. Safety rules for the installation and maintenance of electrical supply stations. 1940. (Supersedes H6). 10c.
- H32. Safety rules for the installation and maintenance of electric supply and communication lines. 1941. (Supersedes H10). 75c.
- H33. Safety rules for the installation and maintenance of electric utilization equipment. 1940. (Supersedes H7). 20c.
- H34. Safety rules for the operation of electric equipment and lines. 1938. (Supersedes C49 and H8). 20c.
- H35. Safety rules for radio installations. 1939. (Supersedes H9). 15c.
- H36. Safety rules for electric fences. 1940. 10c.
- H28. (1944). Screw-thread standards for Federal services.

The purpose of this handbook is to present complete dimensional data upon which specifications may be based for threaded products for Government requirements. So

far as practicable, these data are intended to conform to generally accepted commercial practice, although certain special requirements of the Government necessitate the inclusion of some standards not generally applicable outside of the Government services. References are cited throughout the text to the standards promulgated by the American Standards Association, and to such other published standards as are in agreement with the specifications herein. Feb. 17, 1945. 274 p. \$1.00. Supersedes H28 (1942).

H29. Specifications, tolerances, and regulations for commercial weighing and measuring devices. . . . . Ralph W. Smith

The specifications, tolerances, and regulations published herein comprise all of the current codes as adopted by the National Conference on Weights and Measures, the latest action reported having been taken by the 1941 Conference. The material relates to: apparatus in the metric system, linear measures, fabric-measuring devices, taximeters, odometers, liquid capacity measures; glass graduates, single-service measure-containers (except milk bottles), milk bottles, lubricating-oil bottles, liquid-measuring devices, grease-measuring devices, vehicle tanks, dry capacity measures, berry baskets or boxes, scales, weights; and general regulations relating to position of weighing or measuring device. Sept. 26, 1942. 148 p. 60c. (buckram bound). Supersedes H22.

H30. National electrical safety code.

The National Electrical Safety Code combines five separate parts of the code which have been issued as National Bureau of Standards handbooks H31 to H35, inclusive. The five parts of the code include definitions of terms used in the code, grounding rules, safety rules for the installation and maintenance of electric supply stations, safety rules for the installation and maintenance of electric supply and communication lines, safety rules for the installation and maintenance of electric utilization equipment, safety rules for the operation of electric equipment and lines, and safety rules for radio installations. 1948. (Supersedes H3). \$1.25 (buckram bound).

H37. Testing of weighing equipment. . . . . Ralph W. Smith

A manual for State and local weights and measures officials, describing various types of commercial weighing equipment, the principles of their operation, and methods for their inspection and test. Jan. 31, 1945. 184 p. \$1.00.

H38. Protection of radium during air raids. . . . . L. F. Curtiss

This Handbook contains the recommendations of a special committee appointed by the Director to draft regulations to protect individuals from effects of dispersal of radium during air raids and to provide adequate safeguards for the radium under such conditions. May 4, 1942. 17 p. 10c.

H39. Discussion of the National Electrical Safety Code. Part 2 and Grounding Rules. National Bureau of Standards Advisory Committee for the Preparation of the Discussion Handbook.

This Handbook is a discussion of Part 2 of the Fifth Edition of the National Electrical Safety Code, published as Handbook H32, Safety Rules for the Installation and Maintenance of Electric Supply and Communication Lines. It covers the more important revised requirements in Handbook H32, as well as others that, although substantially unchanged, can be effectively supplemented by a discussion. Three appendices are included. These contain technical data that will be helpful in making computations of the strengths of supporting structures and in determining crossing clearances. In some cases there are suggested engineering short cuts that give approximately the same results as formulas covered in the code. The material was prepared by the National Bureau of Standards Advisory Committee for the Preparation of the Discussion Handbook. July 15, 1944. 162 p. \$1.00 (buckram).

H40. Code for protection against lightning.

This American Standard Code gives basic rules for the protection of persons (part I), protection of buildings and miscellaneous property (part II), and protection of structures containing inflammable liquids and gases (part III).

Detailed specifications are included on number, size, and form of points and rods, grounds, etc., together with detailed instructions for bonding metal roofs and metal-clad buildings.

Sketches of protector masts and the resulting "cone of protection" are included.

A discussion of the origin, characteristics, and effects is included as Appendix A, while Appendix B, consisting of a rather full bibliography, completes the publication. March 22, 1945. 99 p. 20c. Supersedes H21.



## MISCELLANEOUS PUBLICATIONS

As the name implies, this series includes material, which, because of its character or because of its size, does not fit into any of the other regular publication series. Some of these are charts, administrative pamphlets, directories of specifications, annual reports, weights and measures conference reports, and other subjects appropriate to the Miscellaneous series.

- M1. Manual of inspection and information for weights and measures officials. 1918. (Superseded by H1).
- M2. The international metric system of weights and measures. 1906.
- M3. The international metric system. (Chart). 40c.
- M4. First annual conference on the weights and measures of the United States. 1905.
- M5. Second annual conference on the weights and measures of the United States. 1906.
- M6. Third annual conference on the weights and measures of the United States. 1907.
- M7. Fourth annual conference on the weights and measures of the United States. 1908.
- M8. Fifth annual conference on the weights and measures of the United States. 1910.
- M9. Sixth annual conference on the weights and measures of the United States. 1911.
- M10. Seventh annual conference on the weights and measures of the United States. 1912.
- M11. Eighth annual conference on the weights and measures of the United States. 1913.
- M12. Ninth annual conference on the weights and measures of the United States. 1914.
- M13. Tenth annual conference on the weights and measures of the United States. 1915.
- M14. Eleventh annual conference on the weights and measures of the United States. 1916.
- M15. Some technical methods of testing miscellaneous supplies, including paints and paint materials, inks, lubricating oils, soaps, etc. 1916.
- M16. Report to the international committee on electric units and standards. 1912.
- M17. Copper-wire table (English and metric). 1919.
- M18. National Bureau of Standards — description of work of Bureau. 1911. (Superseded by C1).
- M19. Proceedings of the second annual textile conference held at the Bureau of Standards. 1917.
- M20. Laws concerning the weights and measures of the United States. 1st ed. 1904. State and national laws concerning the weights and measures of the United States. 3d ed. 1926. \$2.30.
- M21. Metric manual for soldiers. 1918.
- M22. Annual report of the Director of the National Bureau of Standards for the fiscal year ended June 30, 1902.
- M23. Annual report of the Director of the National Bureau of Standards for the fiscal year ended June 30, 1903.
- M24. Annual report of the Director of the Bureau of Standards to the Secretary of Commerce and Labor for the fiscal year ended June 30, 1904.
- M25. Annual report of the Director of the Bureau of Standards to the Secretary of Commerce and Labor for the fiscal year ended June 30, 1905.
- M26. Annual report of the Director of the Bureau of Standards to the Secretary of Commerce and Labor for the fiscal year ended June 30, 1906.
- M27. Annual report of the Director of the Bureau of Standards to the Secretary of Commerce and Labor for the fiscal year ended June 30, 1907.
- M28. Annual report of the Director of the Bureau of Standards to the Secretary of Commerce and Labor for the fiscal year ended June 30, 1908.
- M29. Annual report of the Director of the Bureau of Standards to the Secretary of Commerce and Labor for the fiscal year ended June 30, 1909.
- M30. Annual report of the Director of the Bureau of Standards to the Secretary of Commerce and Labor for the fiscal year ended June 30, 1910.
- M31. Annual report of the Director of the Bureau of Standards to the Secretary of Commerce and Labor for the fiscal year ended June 30, 1911.

- M32. Annual report of the Director of the Bureau of Standards to the Secretary of Commerce and Labor for the fiscal year ended June 30, 1912.
- M33. Annual report of the Director of the Bureau of Standards to the Secretary of Commerce for the fiscal year ended June 30, 1913.
- M34. Annual report of the Director of the Bureau of Standards to the Secretary of Commerce for the fiscal year ended June 30, 1914.
- M35. Annual report of the Director of the Bureau of Standards to the Secretary of Commerce for the fiscal year ended June 30, 1915.
- M36. Annual report of the Director of the Bureau of Standards to the Secretary of Commerce for the fiscal year ended June 30, 1916.
- M37. Annual report of the Director of the Bureau of Standards to the Secretary of Commerce for the fiscal year ended June 30, 1917.
- M38. Annual report of the Director of the Bureau of Standards to the Secretary of Commerce for the fiscal year ended June 30, 1918.
- M39. Household weights and measures. (Card). 2d ed. 1920.
- M40. Annual report of the Director of the Bureau of Standards to the Secretary of Commerce for the fiscal year ended June 30, 1919.
- M41. Report of the twelfth annual conference on weights and measures. 1919.
- M42. Progress report of the National Screw Thread Commission. 1921.
- M43. Thirteenth annual conference on the weights and measures of the United States. 1920. 20c.
- M44. Annual report of the Director of the Bureau of Standards to the Secretary of Commerce for the fiscal year ended June 30, 1920.
- M45. Buying commodities by weight or measure. 1920.
- M46. War work of the Bureau of Standards. 1921.
- M47. Annual report of the Director of the Bureau of Standards to the Secretary of Commerce for the fiscal year ended June 30, 1921.
- M48. Fourteenth annual conference on the weights and measures of the United States. 1921. 20c.
- M49. Graphic comparison of screw thread pitches. 1922.
- M50. Annual report of the Director of the Bureau of Standards to the Secretary of Commerce for the fiscal year ended June 30, 1922.
- M51. Fifteenth annual conference on the weights and measures of the United States. 1922. 15c.
- M52. Mollier chart of properties of ammonia. 1923. (Included in C142).
- M53. Annual report of the Director of the Bureau of Standards to the Secretary of Commerce for the fiscal year ended June 30, 1923.
- M54. A standard state zoning enabling act. 1924. (Reissued as BH5).
- M55. Sixteenth annual conference on the weights and measures of the United States. 1923. 30c.
- M56. Tables and graphs for facilitating the computation of spectral energy distribution by Planck's formula. 1925.
- M57. Large Mollier chart. 1924.
- M58. Technical conference of state utility commission engineers. 1923.
- M59. Seventeenth annual conference on the weights and measures of the United States. 1924. 35c.
- M60. Annual report of the Director of the Bureau of Standards to the Secretary of Commerce for the fiscal year ended June 30, 1924.
- M61. 1924 report of the National Screw Thread Commission.
- M62. Table of Brinell hardness numbers. 1924.
- M63. Report of board of visitors to Bureau of Standards of the Department of Commerce for the Secretary of Commerce. 1923.
- M64. The standard weights and measures of the United States. 1925.
- M65. National directory of commodity specifications: classified and alphabetical lists and brief descriptions of existing commodity specifications. 1925. (Superseded by M130).
- M66. Second Technical Conference of State Utility Commission Engineers. 1924.
- M67. Kilocycle-meter conversion table. 1925.
- M68. Adjust your headlights. 1925.
- M69. Annual report of the Director of the Bureau of Standards to the Secretary of Commerce for the fiscal year ended June 30, 1925.
- M70. Report of eighteenth national conference on weights and measures of the United States. 1925. 50c.
- M71. Compressibilities of gases. 1925.
- M72. Strain lines developed by compressive tests on structural members of the Delaware River Bridge at the United States Bureau of Standards for the Delaware River Bridge Joint Commission. 1926.



- M73. Subject index of United States Government Master specifications. 1926.  
(Superseded by C319).
- M74. Report of nineteenth national conference on weights and measures. 1926.
- M75. Annual report of the Director of the Bureau of Standards to the Secretary of  
Commerce for the fiscal year ended June 30, 1926.
- M76. Mollier chart, properties of ammonia. 1927. 10c.
- M77. Standards yearbook, 1927.
- M78. Standard atmosphere chart. 1927. (Superseded by M82).
- M79. Standards and specifications in the wood-using industries. 1927.
- M80. Report of the twentieth national conference on weights and measures. 1927.  
45c.
- M81. Annual report of the Director of the Bureau of Standards to the Secretary of  
Commerce for the fiscal year ended June 30, 1927.
- M82. Standard atmosphere chart. 1927. (Supersedes M78).
- M83. Standards yearbook, 1928. \$1.00.
- M84. Standard time conversion chart. 2d ed. 1931.
- M85. Specifications and tolerances for commercial weighing and measuring devices.  
1929. (Supersedes H1 and C61. Superseded by H22).
- M86. Tables of spectral energy distribution and luminosity for use in computing  
light transmissions and relative brightness from spectrophotometric data.  
1929. 10c.
- M87. Report of the twenty-first national conference on weights and measures. 1928.  
35c.
- M88. Annual report of the Director of the Bureau of Standards to the Secretary of  
Commerce for the year ended June 30, 1928.
- M89. Report of the National Screw Thread Commission. 1928. (Supersedes M61.  
Superseded by H28).
- M90. Directory of commercial testing and college research laboratories. 1927.  
(Superseded by M125).
- M91. Standards yearbook, 1929. \$1.00.
- M92. Code for protection against lightning. 1929. (Superseded by H21).
- M93. Visitors' manual of the National Bureau of Standards. 1929. (Superseded by  
M134).
- M94. Scientific and technical positions in the Bureau of Standards. 1929. (Super-  
seded by M152).
- M95. Protection against lightning. 1929. (Reissued as H13).
- M96. Organizations cooperating with the National Bureau of Standards. 1930.
- M97. Thermal properties of petroleum products. 1929. 15c.
- M98. American national screw thread tables for shop use. I. Standard threads (coarse  
and fine thread series). 1929.
- M99. American national screw thread tables for shop use. II. Special threads. 1929.
- M100. Plain and threaded plug and ring gage blanks. 1930. (Superseded by CS8).
- M101. Report of twenty-second national conference on weights and measures. 1929.  
30c.
- M102. Annual report of the Director of the Bureau of Standards to the Secretary  
of Commerce for the fiscal year ended June 30, 1929.
- M103. Weights and measures references. Including an index to the reports of the  
national conference on weights and measures from the first to the twenty-  
first, inclusive. 1930.
- M104. Testing equipment for large-capacity scales for the use of weights and measures  
officials. 1930. 10c.
- M105. Certification plan — significance and scope. 1930.
- M106. Standards yearbook, 1930. 75c.
- M107. Safety code for brakes and brake testing. 1930.
- M108. The manufacture and properties of a cellulose product (maizolith) from corn-  
stalks and corn cobs. 1930.
- M109. Chart for determining the helix angles of screw threads. 1930.
- M110. Standards and specifications for nonmetallic minerals and their products.  
1930.
- M111. Standard time zones of the United States and adjacent parts of Canada and  
Mexico. (Map). 1930. (Superseded by M155).
- M112. Manufacture of insulating board from corn stalks. 1930.
- M113. Simplification of sizes and terminology of high volatile bituminous coal.  
1930. 5c.
- M114. Filters for the reproduction of sunlight and daylight and the determination  
of color temperature. 1931. 45c.

- M115. Annual report of the Director of the Bureau of Standards to the Secretary of Commerce for the fiscal year ended June 30, 1930.
- M116. Report of the twenty-third national conference on weights and measures. 1930. 35c.
- M117. Units used to express the wave lengths of electromagnetic waves. 1930.
- M118. The optical rotation of liquids, its variation with wave length, temperature, solvent, and concentration. T. Martin Lowry. 1932. 10c.
- M119. Standards yearbook, 1931. \$1.00.
- M120. Standards and specifications for metals and metal products. George A. Ward-law. 1933.
- M121. Units of weight and measure (United States customary and metric) definitions and tables of equivalents. 1936. (Supersedes C47). 30c.
- M122. Weights and measures in Congress. Sarah Ann Jones. 1936.
- M123. Production of pressboard from cornstalks. Baker Wingfield, T. R. Naffziger, E. R. Whittemore, C. B. Overman, O. R. Sweeney, and S. F. Acree. 1936. 5c.
- M124. Paper pulp from cereal straws by a modified sulfate process. Baker Wingfield, T. R. Naffziger, E. R. Whittemore, C. B. Overman, O. R. Sweeney, and S. F. Acree. 1936. 5c.
- M125. Directory of commercial testing and college research laboratories. Ann E. Rapuzzi. 1936. (Supersedes M90. Superseded by M171).
- M126. Temperature interconversion tables ( $^{\circ}\text{C} \rightleftharpoons ^{\circ}\text{F}$ ) and melting points of the chemical elements. 1937. (Supersedes C35. Superseded by M183).
- M127. Permeability of membranes to water vapor with special reference to packaging materials. Frederick T. Carson. 1937. 5c.
- M128. A survey of storage conditions in libraries relative to the preservation of records. 1931.
- M129. Report of twenty-fourth national conference on weights and measures. 1931. 50c.
- M130. National directory of commodity specifications. Clarence W. Ingels. 1932. (Supersedes M65. Superseded by M178).
- M131. Annual report of the Director of the Bureau of Standards to the Secretary of Commerce for the fiscal year ended June 30, 1931.
- M132. Properties of fiber building boards. 1931.
- M133. Standards yearbook, 1932.
- M134. Visitor's manual of the Bureau of Standards. Hugh G. Boutell. 1932. (Supersedes M93. Superseded by M153).
- M135. The international metric system of weights and measures. William Parry. 1932. 10c.
- M136. Bibliography on standardization. Anne L. Baden. 1932.
- M137. Paint for priming plaster surfaces. Percy H. Walker and E. F. Hickson. 1932.
- M138. Annual report of the Director of the Bureau of Standards to the Secretary of Commerce for the fiscal year ended June 30, 1932.
- M139. Standards yearbook, 1933.
- M140. A study of deterioration of book papers in libraries. Arthur E. Kimberly and Adelaide L. Emley. 1932. 5c.
- M141. Report of the National Screw Thread Commission. 1933. (Supersedes previous reports. Superseded by H28).
- M142. A study of the removal of sulphur dioxide from library air. Arthur E. Kimberly and Adelaide L. Emley. 1933. 5c.
- M143. Psychrometric charts. Donald B. Brooks. 1933. (Superseded by M146)
- M144. Summary report of Bureau of Standards research on preservation of records. A. E. Kimberly and B. W. Scribner. 1934. (Superseded by M154).
- M145. Preservation of newspaper records. B. W. Scribner. 1934. 5c.
- M146. Psychrometric charts for high and low pressures. Donald B. Brooks. 1935. (Supersedes M143).
- M147. Papermaking quality of cornstalks. Charles G. Weber, Merle B. Shaw, and Martin J. O'Leary. 1935. 5c.
- M148. Separation of cornstalks into long fibers, pith, and fines. E. R. Whittemore, C. B. Overman, and Baker Wingfield. 1935. 5c.
- M149. A basis for a performance specification for women's full-fashioned silk hosiery. Herbert F. Schiefer and Richard S. Cleveland. 1935. 5c.
- M150. Suitability of sweetpotato starch for the beater sizing of paper. Charles G. Weber, Merle B. Shaw, and Martin J. O'Leary. 1935. 5c.
- M151. Design and construction of building exists. 1935. 10c.
- M152. Scientific and technical positions in the National Bureau of Standards. William C. Fewell. 1935. (Supersedes M94. Superseded by M163).



- M153. Visitor's manual of the National Bureau of Standards. Hugh G. Boutell. 1935. (Supersedes M134. Superseded by M160).
- M154. Summary report of National Bureau of Standards research on preservation of records. A. E. Kimberly and B. W. Scribner. 1937. (Supersedes M144). 10c.
- M155. Standard time zones of the United States and adjacent parts of Canada and Mexico. (Map). 1935. (Supersedes M111).
- M156. Report of the twenty-fifth national conference on weights and measures. 1936.
- M157. Report of the twenty-sixth national conference on weights and measures. 1937. 20c.
- M158. Evaluation of motion-picture film for permanent records. John R. Hill and Charles G. Weber. 1937. 5c.
- M159. Report of the twenty-seventh national conference on weights and measures. 1937.
- M160. Visitor's manual of the National Bureau of Standards. Hugh G. Boutell. 1937. (Supersedes M153).
- M161. Report of the twenty-eighth national conference on weights and measures. 1939. 30c.
- M162. Summary report of research at the National Bureau of Standards on the stability and preservation of records on photographic film. B. W. Scribner. 1939. 10c.
- M163. Scientific and technical positions in the National Bureau of Standards. William C. Fewell. 1939. (Supersedes M152).
- M164. Report of the twenty-ninth national conference on weights and measures. 1940. 25c.
- M165. Standardization of packages. 1940. (Reprint from M164). 10c.
- M166. Charts for testing lens resolution. Irvine C. Gardner. 1940.
- M167. Report of the thirtieth national conference on weights and measures. 1941. 55c.
- M168. Protection of documents with cellulose acetate sheeting. B. W. Scribner. 1940. 5c.
- M169. Standardization activities of national technical and trade organizations. Robert A. Martino. 1941. 75c.
- M170. Report of the thirty-first national conference on weights and measures. 1941. 35c.
- M171. Directory of commercial testing and college research laboratories. Ann E. Rapuzzi. 1942. (Supersedes M125. Superseded by M187).
- M172. Index to the reports of the National Conference on Weights and Measures. Ralph W. Smith and William T. McCormac

This publication replaces National Bureau of Standards Miscellaneous Publication M103 with respect to the index of the several Reports of the National Conference on Weights and Measures. The earlier index covered the Conference Reports from the First to the Twenty-first, inclusive; the present publication covers all Conference Reports from the First to the Thirty-first, inclusive. Thus, the large amount of information on a wide variety of weights and measures subjects, which is embraced within the published reports of the proceedings of the National Conference from the first meeting in 1905 through the meeting in 1941, is made more valuable by reason of the means herein provided for locating readily all material on any specific subject and all material presented by any particular speaker. Oct. 14, 1942. 38 p. 10c. (Supersedes M103).

- M173. The grade terminology problem.....Ihler J. Fairchild

Sets forth in digest form the grade terms, designations, and bases for grading or rating for sixty-four commodities and characteristics selected as broadly representative of the various grading and rating systems used in the United States of America. These terminologies and designations are compared in the light of the technical background for each commodity and impartially from the viewpoint of the buyer, seller, the inspection or testing agency, enforceability and provisions for future improvement in a search for the underlying principles and postulates as a general guide in the selection, formulation, or revision of grade designations in the future. Five general conclusions are drawn in order that grade terminology for the future may be further coordinated, simplified, and clarified. March 7, 1944. 29 p.

- M174. American standard building code requirements for masonry.  
Sectional Committee on Building Code Requirements and Good Practice  
Recommendations for Masonry — A41.

Building Code Requirements for Masonry (ASA A41.1-1944) is a complete code

of minimum requirements for masonry construction including definitions, requirements for materials, allowable stresses and general requirements for all types of masonry except reinforced masonry. This document, prepared by American Standards Association Sectional Committee A41 under the sponsorship of the National Bureau of Standards, is one of a series of building code standards prepared by various committees under the jurisdiction of the Building Code Correlating Committee of the American Standards Association. The basis of the requirements of this code is discussed in an appendix. Mar. 15, 1944. 37 p. 15c. (Supersedes BH6.)

M175. Antiscatter treatments for glass.

Frank W. Reinhart, Ruth A. Kronstadt, and Gordon M. Kline

The relative effectiveness of various commercial and experimental antiscatter treatments for glass was investigated at the request of the United States Office of Civilian Defense. A vacuum-concussion apparatus was used to test glass treated with lacquers, tapes, plastic films, and adhesive-fabric combinations. The materials which gave satisfactory results as initially applied were subjected to wet-dry cyclic and heat tests to determine the aging characteristics of the antiscatter materials. Only a few materials retained the particles of glass satisfactorily in the vacuum test after subjection to the two accelerated aging tests. A review is included of the experimental work and experiences of the British in developing treatments for glass to prevent it from scattering when fractured by bomb explosions. June 19, 1944. 31 p. 10c.

M176. Nomographs and charts for transmission lines.....J. A. Dickinson

Chart 1 consists of two conductor loading nomographs from which, the vertical, and transverse wind loadings being given, the total conductor loading may be obtained.

Chart 2 consists of: Bending moments due to wind on a pole; and ultimate resisting moments of wood poles.

Chart 3 is the catenary curve giving values of the sag at points on the catenary curve expressed in percent of the center sag.

These are all full size reproductions of charts appearing in much reduced size in Handbook H39, Discussion Handbook, Part 2, N. E. S. C. Aug. 7, 1944. 3 p. 25c.

M177. Tests of instruments for the determination, indication, or recording of the specific gravities of gases.

Francis A. Smith, John H. Eisman, and E. Carrol Creitz

At the request of the American Society for Testing Materials, the National Bureau of Standards completed in 1941 a critical study of instruments available to industry for the determination, indication, or recording of the specific gravities of gases. Instruments were submitted for test by all interested manufacturers.

The study of 11 instruments with 15 test gases of known specific gravities, comprised determinations of accuracy and reproducibility, of the effects of changes of temperature, relative humidity and water content of the surrounding air, and of sources of error and applicable corrections. The test gases ranged in specific gravity from helium (0.15), in steps of approximately 0.15, to butane (2.06). The probable errors in the values of the specific gravities of the test gases and mixtures used as standards of reference averaged  $\pm 0.0004$ , which made it possible to fix the errors of the instruments to 0.0001 specific gravity unit. Jan. 20, 1947. 143 p. \$1.00.

M178. National directory of commodity specifications.

P. A. Cooley and A. E. Rapuzzi

This is the third edition of the Directory, issued first in 1925, and again in 1932. It contains an alphabetical list of commodities and a thoroughly classified list of the specifications formulated by organizations having national recognition or agencies speaking with the authority of the Federal Government. A special effort has been made to increase the usefulness of the Directory. Where the use to which a commodity is put is not self evident from the title of the specification, a brief statement of this use is given. There is also given a brief summary of each specification so that the reader may to some extent judge for himself whether the scope of the specification fits his particular need. The detailed plans in accordance with which the Directory has been compiled were formulated or approved by an advisory board composed of representatives of 14 national organizations interested in the preparation and utilization of specifications. The commodity classification utilized represents a consolidation and simplification of Schedules A and B developed many years ago by the Bureau of Foreign and Domestic Commerce and used currently by the War Production Board. June 30, 1945. 1311 p. \$4.00.



M178. (Supplement). Supplement to the National directory of commodity specifications.

This is a Supplement to the revised National Directory of Commodity Specifications issued in 1945. The purpose of the Directory is to list and briefly describe the standards, specifications, and codes that are formulated by all nationally known and recognized trade associations or technical societies as well as the specifications of governmental agencies that represent the Federal Government. An alphabetical index lists individual items under their various trade and technical names, giving their decimal classification numbers in order to facilitate the easy location of any item in the publication. The brief summaries covering technical characteristics, scope, and application aid the readers in selecting the specifications that fit their particular needs. The Directory is a convenient means for locating commodity specifications that are in existence. March 1, 1947. 322 p. \$2.25 (buckram bound).

M179. American standard building code requirements for minimum design loads in buildings and other structures.....George N. Thompson

Recommended minimum requirements for use in building codes are presented covering dead, live, wind, and earthquake loads. These have been prepared by American Standards Association Sectional Committee A58 under the sponsorship of the National Bureau of Standards and constitute one of a series of related standards being developed by various committees under the jurisdiction of the Building Code Correlating Committee of the American Standards Association. An appendix presents information intended to assist local committees and officials in applying the requirements. Oct. 18, 1945. 32 p. 10c.

M180. Carbon brush terminals (electric).....Andrew C. Tait

This publication consists of a chart showing stock sizes, types, and varieties of carbon brush terminals for all kinds of rotating electrical apparatus. This chart is a replica of that included in Simplified Practice Recommendation R210-45, Carbon brush terminals (electrical), and is issued separately, on special request of the industry, for wall display purposes. The wall chart will be on heavy paper, in size 16 x 19 inches. June 1, 1945. 1 p. 5c.

M181. Jar rings for use in home canning; their testing and a proposed specification.  
R. H. Taylor, H. G. Wheeler, and F. Benedict

The purpose of this investigation was to correlate properties of jar rings with canning tests conducted at the Bureau of Home Economics. Fifty-four different samples of jar rings obtained from 11 different manufacturers were analyzed for rubber content and measurements were made of tensile strength, ultimate elongation, stress at 100 percent elongation, swelling on processing, indentation by apparatus designed to simulate a jar cap, and hardness. Only the swelling, indentation, and hardness tests made before and after processing bore a relation to the canning failures. The relation was not exact because some failures undoubtedly resulted from excessive variations in the jars and tops. Apparatus was developed for accurately measuring profiles of sealing surfaces. Results of the investigation are expressed in terms of a proposed specification for jar rings. Aug. 29, 1945. 18 p. 10c.

M182. Development of standards for flexible caselining materials.

B. W. Scribner, F. T. Carson and C. G. Weber

An investigation was made to develop improved specifications for sheet materials for lining shipping cases so that the liners would give better service in overseas shipments of supplies, particularly those for our armed forces. The sheetings were given various tests considered to have a bearing on their serviceability, such as strength, stretch, flexibility, resistance to scuffing, puncture, and permeation by water vapor and water. Packages containing the sheetings tested used as liners were subjected to simulated service conditions at a commercial testing laboratory. Correlation of the test data of the sheetings with the results of the simulated service trials indicated the properties that are of importance for satisfactory performance in use. Recommended requirements for these properties are included. Sept. 23, 1946. 23 p. 10c.

M183. Temperature interconversion tables ( $^{\circ}\text{C} \rightleftharpoons ^{\circ}\text{F}$ ) and melting points of the chemical elements.

This four-page chart is a revised edition of Miscellaneous Publication M126. Pages 1 to 3 give interconversion tables from  $^{\circ}\text{C}$  to  $^{\circ}\text{F}$  and  $^{\circ}\text{F}$  to  $^{\circ}\text{C}$ . Page 4 gives a list of the chemical elements, their melting points, and their atomic numbers and weights. April 10, 1947. 4 p. 5c.

M184. U. S. patents on powder metallurgy. . . Raymond E. Jager and Rolla E. Pollard

A total of 2,253 U. S. Patents pertaining to powder metallurgy are classified under four main headings: (A) Production, (B) Handling and Working, (C) Alloying, and (D) Applications. Under these main headings, the patents are listed by number in chronological order, together with the name of the inventor and a short abstract of the patent. Patents issued up to January 1, 1947, are included. July 1, 1947. 139 p. 30c.

M185. Rubber research and technology at the National Bureau of Standards.

Lawrence A. Wood

The paper consists of a summary of the activities of the National Bureau of Standards relating to natural rubber, synthetic rubbers, and related materials. It gives a brief outline of the work carried out in each of 13 different fields of investigation, and concludes with a bibliography of 174 publications by members of the staff of the National Bureau of Standards. May 1, 1947. 22 p. 10c.

M186. Report of the thirty-second National Conference on Weights and Measures.

A report of the proceedings of the thirty-second National Conference on Weights and Measures, held in Washington, D. C., September 26, 27, and 28, 1946, and attended by state, county, and city weights and measures officials. 126 p. 40c.

M187. Directory of commercial and college laboratories. . . . . Anne E. Rapuzzi

A list is given of commercial testing laboratories throughout the country with indications of the types of commodities which they are willing to test and the kinds of tests made. Special care has been exercised to make this list complete. There is also presented a list of laboratories in colleges which are used not only for purposes of instruction, but also to a considerable extent for testing and research work. Information concerning both the commercial laboratories and the colleges is arranged geographically for ready reference purposes. (Supersedes M171.) Aug. 30, 1947. 65 p. 30c.



## SIMPLIFIED PRACTICE RECOMMENDATIONS

"Simplified Practice," in this series, means reduction of excessive variety of manufactured products, or of methods. Simplified Practice Recommendations are records of stock items retained after superfluous variety has been eliminated. These recommendations are developed by voluntary cooperation among manufacturers, distributors, consumers, and others interested, through a regular procedure of the National Bureau of Standards established for that purpose — a procedure designed to insure not only the initial success of a program, but also its continued adjustment to meet changing industrial conditions.

Each printed booklet contains not only the specific recommendation itself, but also its history and development, the names of trade associations, firms, individuals, and others that approved the recommendation, and the personnel of the standing committee in charge of its maintenance and revisions as needed to keep them current with developments. The status of any recommendation at any time may be determined by writing to the Division of Commodity Standards, National Bureau of Standards, Washington 25, D. C. The date from which each recommendation is effective is given.

- R1. Vitrified paving brick. August 15, 1940. 5c.
- R2. Bedsteads, springs and mattresses. November 1, 1932. 5c.
- R3. Metal lath (expanded and sheet) and metal plastering accessories. April 11, 1944. 5c.
- R4. Asphalt. June 15, 1936. 5c.
- R5. Hotel chinaware. January 1, 1924. 5c.
- R6. Files and rasps (American pattern, and curved-tooth milled files). September 15, 1947. 10c.
- R7. Face brick and common brick. June 21, 1923.
- R8. Ferrous range boilers, expansion tanks, and solar tanks. September 1, 1947. 5c.
- R9. Woven-wire fencing; woven-wire fence packages. March 1, 1947. 10c.
- R10. Milk and cream bottles (capacities, weights, dimensions, and finishes). December 31, 1947. 10c.
- R11. Bed blanket sizes. September 15, 1936.
- R12. Hollow building tile. March 1, 1926.
- R13. Structural slate. February 1, 1928.
- R14. Roofing slate. February 1, 1928.
- R15. Blackboard slate. November 1, 1935. 5c.
- R16. Lumber — American lumber standards for softwood lumber. October 15, 1939. 20c.
- R17. Heavy forged hand tools. October 15, 1947. 10c.
- R18. Builders' hardware (nontemplate). (Standards for builders' hardware are set forth in Commercial Standard CS22-40).
- R19. Asbestos paper and asbestos millboard. December 15, 1937. 5c.
- R20. Steel barrels and drums. January 1, 1928.
- R21. Lavatory and sink traps. December 31, 1946. 5c.
- R22. Paper (basic sheet sizes). December 31, 1940. 5c.
- R23. Plow bolts. January 1, 1945. 5c.
- R24. Hospital beds. December 1, 1937. 5c.
- R25. Hot water storage tanks. January 1, 1925.
- R26. Steel reinforcing bars. June 15, 1942. 5c.
- R27. Cotton duck. November 1, 1936. 5c.
- R28. Sheet steel. January 1, 1929.
- R29. Eaves trough, conductor pipe, and fittings and ridge rolls. February 1, 1942. 5c.
- R30. Roofing ternes. January 1, 1942. 5c.
- R31. Loaded paper shot shells. January 2, 1948. 10c.
- R32. Concrete building units. August 1, 1938.
- R33. Cafeteria and restaurant chinaware. January 1, 1925.
- R34. Warehouse forms. September 24, 1924. 10c.
- R35. Steel lockers (single, double, and multiple tier). September 16, 1944. 5c.

- R36. Milling cutters. March 15, 1934.
- R37. Commercial forms (invoice, purchase order and inquiry.) Feb. 16, 1927. (Reissued in August 1938). 10c.
- R38. Sand-lime brick. June 15, 1937. 5c.
- R39. Dining-car chinaware. July 1, 1925. 5c.
- R40. Hospital chinaware. July 1, 1925. 5c.
- R41. Agricultural insecticide and fungicide (package sizes). November 1, 1942. 5c.
- R42. Grocers' paper bags. March 1, 1943. 5c.
- R43. Paint and varnish brushes. December 15, 1927. 5c.
- R44. Box board thicknesses. December 31, 1936. 5c.
- R45. Grinding wheels. July 1, 1947. 15c.
- R46. Tissue paper. June 15, 1939. 5c.
- R47. Cut tacks and small cut nails. July 1, 1928. 10c.
- R48. Shovels, spades, scoops, and telegraph spoons. September 1, 1942. 5c.
- R49. Sidewalk, floor and roof lights. March 1, 1926. 5c.
- R50. Bank checks, notes, drafts, and similar instruments. March 1, 1926.
- R51. Chasers for self-opening and adjustable die heads. July 1, 1929. 10c.
- R52. Staple vitreous china plumbing fixtures. September 30, 1936. (Included in Commercial Standard CS20-42).
- R53. Steel reinforcing spirals. December 15, 1932. 5c.
- R54. Sterling silver flatware. January 1, 1926.
- R55. Tinware, galvanized and japanned ware. July 1, 1926.
- R56. Carbon brushes (carbon, graphite, and metal-graphite) and brush shunts. June 15, 1936. 5c.
- R57. Wrought-iron and wrought-steel pipe, valves, and fittings. October 1, 1932. 5c.
- R58. Classification of iron and steel scrap. June 15, 1936. 5c.
- R59. Rotary-cut lumber stock for wire-bound boxes. November 1, 1926. 5c.
- R60. Packaging of carriage, machine, and lag bolts. November 15, 1943. 5c.
- R61. Clay tiles for floors and walls. September 1, 1944. 10c.
- R62. Metallic cartridges. January 2, 1948. 10c.
- R63. Metal spools (for annealing, handling, and shipping wire). January 1, 1928. 5c.
- R64. One-pound folding boxes for coffee. July 1, 1930. 5c.
- R65. Packaging of overhead electric railway material. October 1, 1931. 5c.
- R66. Automobile brake lining. December 1, 1927. 5c.
- R67. Taper roller bearings. January 1, 1936.
- R68. Metal and nonconducting flashlight cases. June 1, 1941. 5c.
- R69. Packaging of razor blades. July 1, 1928. 5c.
- R70. Salt packages. September 1, 1946. 5c.
- R71. Turnbuckles. January 1, 1928. 5c.
- R72. Solid section steel windows. September 1, 1927.
- R73. One-piece porcelain insulators. October 1, 1927. 5c.
- R74. Hospital and institutional cotton textiles. July 1, 1930. 5c.
- R75. Composition blackboard. April 1, 1929. 5c.
- R76. Ash handles. August 1, 1940. 5c.
- R77. Hickory handles. November 1, 1945. 5c.
- R78. Iron and steel roofing. June 1, 1928. 5c.
- R79. Malleable foundry refractories. February 1, 1928. 10c.
- R80. Folding and portable wooden chairs. March 15, 1928. 5c.
- R81. Binders' board. March 1, 1928. 5c.
- R82. Hollow metal single acting swing doors, frames and trim. August 1, 1928.
- R83. Kalamein doors. April 1, 1928.
- R84. Composition books. September 1, 1928. 5c.
- R85. Adhesive plaster. October 1, 1947. 5c.
- R86. Surgical gauze. June 1, 1947. 5c.
- R87. Forms for concrete joist construction floors. May 1, 1932. 5c.
- R88. Floor sweeps. June 1, 1937. 5c.
- R89. Coated abrasive products. May 15, 1946. 10c.
- R90. Hack-saw blades. January 15, 1946. 10c.
- R91. Glass containers for preserves, jellies and apple butter. December 15, 1932.
- R92. Hard fiber twine and lath yarn (ply and yarn goods). April 1, 1938.
- R93. Paper shipping tags. March 1, 1939. 5c.
- R94. Open-web steel joists. October 1, 1930. 5c.
- R95. Skid platforms. October 1, 1930. 5c.
- R96. Ice cake sizes. October 1, 1928. 5c.
- R97. Bell-bottom screw jacks. June 1, 1947. 5c.
- R98. Photographic paper. August 1, 1943. 5c.



- R99. Pocket knives. January 1, 1930. 10c.
- R100. Welded chain. January 2, 1947. 10c.
- R101. Metal partitions for toilets and showers. December 1, 1940. 5c.
- R102. Granite curbstone. January 15, 1933. 5c.
- R103. Industrial truck and trailer solid tires. June 1, 1934. 5c.
- R104. Packaging of flashlight batteries. July 1, 1930. 5c.
- R105. Wheelbarrows. April 1, 1932. 5c.
- R106. Hospital plumbing fixtures. July 1, 1941. 5c.
- R107. Glassine bags. October 15, 1931. 5c.
- R108. Dental hypodermic needles. June 15, 1944. 5c.
- R109. Refrigerator ice compartments. October 1, 1929.
- R110. Soft fiber (jute) twine. November 1, 1929. 10c.
- R111. Color for school furniture. January 2, 1930.
- R112. Elastic shoe goring. November 1, 1929. 5c.
- R113. Restaurant guest checks. February 2, 1930. 5c.
- R114. No. 1 Kraft paper sealing tape. February 1, 1930. 10c.
- R115. Full disk buffing wheels. February 2, 1930. 5c.
- R116. Dental brush wheels. February 1, 1931. 10c.
- R117. Packaging of dental plaster, investment and artificial stone. November 1, 1930. 5c.
- R118. Abrasive grain sizes. April 1, 1945. 5c.
- R119. Fast selva terry towels. March 1, 1931. 5c.
- R120. Ice-cream brick molds and cartons. June 30, 1940. 5c.
- R121. Calcimine brushes (block sizes). March 2, 1931. 5c.
- R122. Wire insect screen cloth. November 1, 1931.
- R123. Carbonated beverage bottles. May 1, 1943. 5c.
- R124. Polished cotton twine. November 1, 1931. 5c.
- R125. Waxed tissue paper. November 1, 1931. 5c.
- R126. Set-up paper boxes (used by department and specialty stores). January 1, 1941. 5c.
- R127. Folding paper boxes (used by department and specialty stores). January 1, 1941. 5c.
- R128. Corrugated paper boxes (used by department and specialty stores). January 1, 1941. 5c.
- R129. Notion and millinery paper bags (used by department and specialty stores). January 1, 1941. 5c.
- R130. Dental lathe grinding wheels. January 1, 1932. 5c.
- R131. Glass containers for mayonnaise and kindred products. January 1, 1935. 5c.
- R132. Ice cream cups and cup caps. July 1, 1936. 5c.
- R133. Surgical dressings. July 1, 1947. 10c.
- R134. Singletrees, doubletrees and neckyokes. April 1, 1932. 5c.
- R135. Wooden butter tubs. January 1, 1932. 5c.
- R136. Flax and hemp twine. June 15, 1932. 5c.
- R137. Dental cone-socket mirrors. September 1, 1932. 5c.
- R138. Dental rubber (base and veneering). September 1, 1932. 5c.
- R139. Commercial laundry extractors. October 1, 1932. 5c.
- R140. Commercial laundry flat-work ironers. October 1, 1932. 5c.
- R141. Commercial laundry tumblers. October 1, 1932. 5c.
- R142. Commercial laundry washers. October 1, 1932. 5c.
- R143. Paper cones and tubes (for textile winding). October 15, 1939. 5c.
- R144. Paints, varnishes, and related products (colors and containers). November 1, 1945. 5c.
- R145. Packaging of electric railway motor and controller parts. March 15, 1933. 5c.
- R146. Corrugated and solid fiber boxes for canned fruits and vegetables. December 1, 1941. 5c.
- R147. Wire diameters for mineral aggregate production screens. June 30, 1942. 5c.
- R148. Glass containers for cottage cheese and sour cream (capacities, weights, dimensions, and finish). December 31, 1947. 10c.
- R149. Sieve (screen) sizes of canned peas. May 1, 1933. 5c.
- R150. Copper wire nails. July 1, 1934. 5c.
- R151. To be assigned.
- R152. Basic dimensions for cones for warp and knitting yarns and hole sizes for bobbins for filling cop winders. March 1, 1934. 5c.
- R153. Hole sizes for taper tubes for filling cop winders. March 1, 1934. 5c.
- R154. Cupola refractories. October 1, 1938. 10c.
- R155. Cans for fruits and vegetables (names, dimensions, capacities, and designated use). September 1, 1940.
- R156. Extracted-honey packages. June 1, 1941. 5c.

- R157. Steel horizontal firebox heating boilers. January 1, 1937. 5c.
- R158. Forged axes. November 17, 1942. 5c.
- R159. Forged light hammers. November 17, 1942. 5c.
- R160. Forged hatchets. November 17, 1942. 5c.
- R161. Packaging of automotive (bus) engine parts. September 1, 1935.
- R162. Packaging of air brake (electric railway) parts. September 1, 1935. 5c.
- R163. Coarse aggregates (crushed stone, gravel and slag). May 25, 1939.
- R164. Tinned-steel ice cream cans. July 1, 1936. 5c.
- R165. Photographic film for miniature copies of records. August 1, 1936.
- R166. Color code for marking steel bars. April 1, 1937. 5c.
- R167. Counter, window and radiator brushes. June 1, 1937. 5c.
- R168. Braided shoe laces. June 15, 1937. 5c.
- R169. Bolts and nuts (stock-production sizes). October 1, 1945. 10c.
- R170. Spice containers (tin and fiber). June 15, 1938. 5c.
- R171. Wooden boxes for canned fruit and vegetables. July 1, 1938. 5c.
- R172. Stock folding boxes for garments and dry cleaning. September 1, 1938. 5c.
- R173. Stock folding boxes for millinery. September 1, 1938. 5c.
- R174. Cast-iron radiators. January 1, 1947. 5c.
- R175. Heavy-duty, round, nesting, paper, food and beverage containers and lids. September 15, 1940. 5c.
- R176. Color marking for anesthetic gas cylinders. January 29, 1941. 5c.
- R177. Single-faced corrugated-board rolls (used by department and specialty stores). January 1, 1941. 5c.
- R178. Packaging of first-aid unit dressings and treatments. June 30, 1941. 5c.
- R179. Structural insulating board (vegetable fiber). December 15, 1946. 5c.
- R180. Copper conductors for building purposes. July 1, 1941. 5c.
- R181. Non-ferrous range boilers. July 1, 1941. 5c.
- R182. Food service equipment. October 1, 1941. 5c.
- R183. Brass or bronze valves (gate, globe, angle, and check). September 1, 1946. 5c.
- R184. Iron valves (gate, globe, angle, and check). March 1, 1947. 5c.
- R185. Pipe fittings (gray cast iron, malleable iron, and brass or bronze). September 1, 1947. 10c.
- R186. Cotton canton flannels for work gloves. November 1, 1944. 5c.
- R187. Food trays, or dishes (waxed paper, molded wood pulp, and wood types). April 1, 1942. 5c.
- R188. Spring and slotted clothespins (sizes and packaging). April 1, 1942. 5c.
- R189. Round and flat hardwood toothpicks (packaging and sizes). April 1, 1942.
- R190. Stove pipe and accessories. August 1, 1942. 5c.
- R191. School tables. January 1, 1943. 5c.
- R192. Crayons, chalks, and related art materials for school use (types, sizes, packaging, and colors). May 1, 1945. 5c.
- R193. Packages for shortening, salad oil, and cooking oil. July 1, 1942. 5c.
- R194. Cotton jersey cloth and tubing for work gloves. June 1, 1942. 5c.
- R195. Dental excavating burs. September 1, 1946. 5c.
- R196. Glass containers for green olives (capacities, dimensions, and packaging). November 1, 1942. 5c.
- R197. Glass containers for maraschino cherries (capacities, dimensions, and packaging). November 1, 1946. 5c.
- R198. Wire rope. February 15, 1943. 10c.
- R199. Cloth window shades. March 1, 1943. 5c.
- R200. Paper boxes for toiletries and cosmetics. July 1, 1943. 5c.
- R201. Iron and steel pop safety valves. September 15, 1943. 5c.
- R202. Air compressors for automotive service stations and garages (motor driven,  $\frac{1}{2}$  to 10 horsepower). December 1, 1943. 5c.
- R203. Containers and packages for household insecticides (liquid spray type). January 1, 1944. 5c.
- R204. Bronze pop safety valves, and bronze, iron, and steel relief valves. February 1, 1944. 5c.
- R205. Iron and steel relief valves for petroleum, chemical, and general industrial services. October 1, 1944. 5c.
- R206. Swiss pattern files. October 6, 1944. 5c.
- R207. Pipes, ducts, and fittings for warm-air heating and air conditioning. March 1, 1945. 10c.
- R208. Fluid milk cans. August 1, 1946. 5c.
- R209. Peanut butter packages and containers. June 1, 1945. 5c.
- R210. Carbon-brush terminals (electric). July 15, 1945. 5c.



- R211. Clay sewer pipe and fittings. May 31, 1945. 10c.
- R212. Cast-brass solder-joint fittings. July 1, 1945. 5c.
- R213. Asphalt roll roofing and asphalt- and tar-saturated-felt products. November 15, 1945. 5c.
- R214. Metal-cutting band saws (hard edge, flexible back), December 17, 1945. 5c.
- R215. Luggage. January 1, 1946. 5c.
- R216. Hot-rolled carbon steel structural shapes. February 15, 1946. 10c.
- R217. Copper water tube and copper and brass pipe. March 15, 1946. 5c.
- R218. Paper tubes for packaging milk-bottle caps. March 1, 1946. 5c.
- R219. Automatic regulating valves. April 1, 1946. 5c.
- R220. Open-end and box wrenches. April 15, 1946. 5c.
- R221. Steel rivets (stock production sizes). June 1, 1946. 5c.
- R222. Hot-rolled carbon steel bars and bar-size shapes (produced from billets or blooms). June 30, 1946. 10c.
- R223. Wire nails and staples. March 1, 1947. 10c.
- R224. Medical and surgical hypodermic needles (for hospital use). January 1, 1947. 5c.
- R225. Asphalt tile. March 1, 1947. 5c.

## COMMERCIAL STANDARDS

Commercial standards are voluntary, recorded standards agreed upon by producers, distributors, and consumers, covering terminology, types, classifications, grades, sizes, and use characteristics of manufactured products as a basis for better understanding between buyers and sellers. They generally include standard methods of test, rating, certification, and labeling, and provide a uniform basis for fair competition. Each standard includes a list of members of the standing committee, a history of the project, a list of acceptors, and, except for recent issues, a list of other commercial standards.

The first date at the end of the abstract is the date the standard became effective; the second date, where given, is the date designated for clearance of nonstandard items from existing stocks.

Where prices are omitted, the standard may, in general, be consulted at the leading technical and public libraries, or be obtained in mimeographed form from the National Bureau of Standards.

- CS0. Commercial Standards and their value to business. Free from Bureau.
- CS1. Clinical thermometers (3d ed.) Feb. 20, 1942. 10c.
- CS2. Mopsticks. Oct. 15, 1930. 5c.
- CS3. Stoddard solvent (dry cleaning). (3d ed.) June 20, 1940. 10c.
- CS4. Staple porcelain (all-clay) plumbing fixtures. Jan. 1, 1930.
- CS5. Pipe nipples; brass, copper, steel, and wrought iron. Feb. 15, 1946. 5c.
- CS6. Wrought-iron pipe nipples. (Superseded by CS5).
- CS7. Standard weight malleable iron or steel screwed unions. May 1, 1930.
- CS8. Gage blanks (3d ed.) Jan. 1, 1942. 20c.
- CS9. Builders' template hardware (2d ed.) Jan. 1, 1933. 10c.
- CS10. Brass pipe nipples. (Superseded by CS5).
- CS11. Moisture regains of cotton yarns (2d ed.) Aug. 1, 1941. 5c.
- CS12. Fuel oils. (5th ed.) Jan. 5, 1940. 5c.
- CS13. Dress patterns (4th ed.) Oct. 20, 1944. 5c.
- CS14. Boys' button-on waists, shirts, junior and sport shirts. (3d ed.). Aug. 20, 1943. 5c.
- CS15. Men's pajama sizes — woven fabrics. (4th ed.). July 20, 1946. 5c.
- CS16. Wall paper. Oct. 19, 1929.
- CS17. Diamond core drill fittings. (3d ed.) July 1, 1947. 10c.
- CS18. Hickory golf shafts. Nov. 1, 1929. 10c.
- CS19. Foundry patterns of wood (2d ed.) Feb. 10, 1930.
- CS20. Staple vitreous china plumbing fixtures (3d ed.) July 10, 1942. 10c.
- CS21. Interchangeable ground-glass joints, stopcocks, and stoppers. (4th ed.) Feb. 15, 1939.
- CS22. Builder's hardware (nontemplate) (2d ed.) July 1, 1940. 10c.
- CS23. Feldspar. Sept. 1, 1930.
- CS24. Screw threads and tap-drill sizes. (Revision and consolidation of CS24-30 and CS25-30). Feb. 10, 1943. 15c.
- CS25. American national special screw threads. (Superseded by CS24).
- CS26. Aromatic red cedar closet lining. Oct. 1, 1930.
- CS27. Mirrors (2d ed.) Aug. 20, 1936.
- CS28. Cotton fabric tents, tarpaulins, and covers. (2d ed.) April 15, 1946. 5c.
- CS29. Staple seats for water-closet bowls. Oct. 1, 1931.
- CS30. Colors for sanitary ware. July 1, 1931.
- CS31. Wood shingles (4th ed.) Oct. 1, 1938. 5c.
- CS32. Cotton cloth for rubber and pyroxylin coating. June 15, 1931. 5c.
- CS33. Knit underwear (exclusive of rayon). July 30, 1943. 20c.
- CS34. Bag, case, and strap leather. Aug. 1, 1931. 5c.
- CS35. Hardwood plywood. Feb. 20, 1947. 10c.
- CS36. Fourdrinier wire cloth. (2d ed.) March 15, 1933.
- CS37. Steel bone plates and screws. Nov. 16, 1931. 10c.
- CS38. Hospital rubber sheeting. June 1, 1932.
- CS39. Wool and part-wool blankets. (2d ed.) May 27, 1937.
- CS40. Surgeons' rubber gloves. July 6, 1932. 5c.
- CS41. Surgeons' latex gloves. July 6, 1932. 5c.
- CS42. Fiber insulating board. (3d ed.) Aug. 25, 1943. 5c.



- CS43. Grading of sulphonated (sulphated) oils. Saponifiable types. Sept. 1, 1932.
- CS44. Apple wraps. Dec. 1, 1932. 5c.
- CS45. Douglas fir plywood. Sept. 15, 1947. 10c.
- CS45E. Douglas fir plywood (export grades). Nov. 1, 1936. 5c.
- CS46. Hosiery lengths and sizes. (3d ed.) Aug. 15, 1940. 10c.
- CS47. Marking of gold-filled and rolled-gold-plate articles other than watch cases. July 1, 1934. 5c.
- CS48. Domestic burners for Pennsylvania anthracite (underfeed type). (2d ed.) Nov. 30, 1940. 5c.
- CS49. Chip board, laminated chip board, and miscellaneous boards for book-binding purposes. Dec. 15, 1934. 5c.
- CS50. Binders board for bookbinding and other purposes. Oct. 1, 1934. 5c.
- CS51. Marking articles made of silver in combination with gold. July 1, 1936. 5c.
- CS52. 100-percent mohair plain velvet, 100-percent mohair plain frieze, and 50-percent mohair plain frieze. July 8, 1935. 5c.
- CS53. Colors and finishes for cast stone. Aug. 30, 1935. 5c.
- CS54. Mattresses for hospitals. Sept. 6, 1935. 5c.
- CS55. Mattresses for institutions. Sept. 6, 1935. 5c.
- CS56. Oak flooring (2d ed.) Feb. 1, 1941. 5c.
- CS56E. Oak flooring (exports). Feb. 5, 1941. 5c.
- CS57. Book cloths, buckrams, and impregnated fabrics for bookbinding purposes except library bindings. (2d ed.) June 20, 1940. 5c.
- CS58. Woven elastic fabrics for use in overalls (overall elastic webbing). May 15 1936. 5c.
- CS59. Textiles — testing and reporting (4th ed.) Feb. 20, 1944. 15c.
- CS60. Hardwood dimension lumber. Oct. 1, 1936. 10c.
- CS60E. Hardwood dimension lumber (exports). July 1, 1941. 5c.
- CS61. Wood-slat venetian blinds. Sept. 1, 1937. 5c.
- CS62. Colors for kitchen accessories. Jan. 1, 1938. 5c.
- CS63. Colors for bathroom accessories. Jan. 1, 1938. 5c.
- CS64. Walnut veneers. Dec. 15, 1937. 5c.
- CS65. Methods of analysis and of reporting fiber composition of textile products. (2d ed.) Feb. 20, 1943. 5c.
- CS66. Marking of articles made wholly or in part of platinum. June 20, 1939. 5c.
- CS67. Marking articles made of karat gold. Nov. 25, 1939. 5c.
- CS68. Liquid hypochlorite disinfectant, deodorant and germicide. June 10, 1938. 5c.
- CS69. Pine oil disinfectant. June 10, 1938. 5c.
- CS70. Phenolic disinfectant (emulsifying type). (2d ed.) Feb. 1, 1941. 5c.
- CS71. Phenolic disinfectant (soluble type). (2d ed.) Feb. 1, 1941. 5c.
- CS72. Household insecticide (liquid spray type). June 10, 1938.
- CS73. Old growth Douglas fir standard stock doors. (3d ed.) Sept. 20, 1945. 10c.
- CS74. Solid hardwood wall paneling. May 20, 1939. 5c.
- CS75. Automatic mechanical draft oil burners designed for domestic installations. (2d ed.) July 20, 1942. 10c.
- CS76. Hardwood interior trim and molding. Oct. 25, 1939. 5c.
- CS77. Sanitary cast-iron enameled ware. May 25, 1940. 5c.
- CS78. Ground-and-polished lenses for sun glasses. Oct. 10, 1939. 5c.
- CS79. Blown, drawn, and dropped lenses for sun glasses. Oct. 10, 1939. 5c.
- CS80. Electric direction signal systems for vehicles (after market). Jan. 1, 1941. 5c.
- CS81. Adverse-weather lamps for vehicles (after market). Jan. 1, 1941. 5c.
- CS82. Inner-controlled spotlamps for vehicles (after market). Jan. 1, 1941. 5c.
- CS83. Clearance, marker, and identification lamps for vehicles (after market). Jan. 1, 1941. 5c.
- CS84. Electric tail lamps for vehicles (after market). Jan. 1, 1941. 5c.
- CS85. Electric license-plate lamps for vehicles (after market). Jan. 1, 1941. 5c.
- CS86. Electric stop lamps for vehicles (after market). Jan. 1, 1941. 5c.
- CS87. Red electric warning lanterns. Jan. 1, 1941. 5c.
- CS88. Liquid-burning flares. Jan. 1, 1941. 5c.
- CS89. Hardwood stair treads and risers. Oct. 10, 1940. 5c.
- CS90E. Crawler mounted, revolving power shovels, lifting cranes, dragline and clamshell excavators (export classifications). Feb. 15, 1947. 15c.
- CS91. Factory-fitted Douglas fir entrance doors. Feb. 10, 1941. 5c.
- CS92. Cedar, cypress, and redwood tank stock lumber. Apr. 15, 1941. 5c.
- CS93. Portable electric drills (exclusive of high frequency). Oct. 18, 1941. 5c.
- CS94. Calking lead. June 25, 1941. 5c.
- CS95. Lead pipe. June 25, 1941. 5c.

- CS96. Lead traps and bends. June 25, 1941. 5c.
- CS97. Electric supplementary driving and passing lamps for vehicles (after market). Jan. 8, 1942. 5c.
- CS98. Artists' oil paint. May 10, 1942. 5c.
- CS99. Gas floor furnaces (gravity circulating type). May 25, 1942. 5c.
- CS100. Porcelain-enamelled steel utensils. (2d ed.) Oct. 25, 1944. 10c.
- CS101. Flue-connected oil-burning space heaters equipped with vaporizing pot-type burners. Jan. 1, 1943. 10c.
- CS102E. Diesel and fuel-oil engines (export classifications). Oct. 30, 1942. 10c.
- CS103. Cotton and rayon velour (jacquard and plain). Nov. 10, 1942. 5c.
- CS104. Warm-air furnaces equipped with vaporizing pot-type oil burners. Oct. 1, 1946. 15c.
- CS105. Mineral wool; loose, granulated, or felted form, in low-temperature installations. March 1, 1943. 5c.
- CS106. Boys pajama sizes (woven fabrics). Dec. 9, 1944. 5c.
- CS107. Commercial electric-refrigeration condensing units.
- CS108. Treading automobile and truck tires. June 10, 1943. 10c.
- CS109. Solid-fuel-burning forced-air furnaces. May 10, 1944. 10c.
- CS110. Tire repairs, vulcanized (passenger, truck and bus tires). Aug. 20, 1943. 5c.
- CS111. Earthenware (vitreous glazed) plumbing fixtures. Oct. 15, 1943. 5c.
- CS112. Homogenous fiber wallboard. Oct. 25, 1943. 5c.
- CS113. Oil-burning floor furnaces equipped with vaporizing pot-type burners. Feb. 17, 1944. 10c.
- CS114. Hospital sheeting for mattress protection. Dec. 1, 1943. 5c.
- CS116. Bituminized-fibre drain and sewer pipe. March 10, 1944. 5c.
- CS117. Mineral wool: Blankets, blocks, insulating cement, and pipe insulation for heated industrial equipment. May 25, 1944. 10c.
- CS118. Marking of jewelry and novelties of silver. Aug. 15, 1944. 5c.
- CS(E)119. Dial indicators (for linear measurements). Jan. 1, 1945. 5c.
- CS120. Standard stock ponderosa pine doors. Oct. 1, 1946. 10c.
- CS121. Women's slip sizes (woven fabrics). April 20, 1945. 5c.
- CS122. Western hemlock plywood. March 5, 1945. 5c.
- CS123. Grading of diamond powder. May 5, 1945. 5c.
- CS(E)124. Master disks. Sept. 15, 1945. 5c.
- CS125. Prefabricated homes. Nov. 25, 1947. 10c.
- CS126. Tank mounted air compressors. Dec. 5, 1945. 10c.
- CS127. Self-contained mechanically refrigerated drinking water coolers. Effective six months after official announcement of cessation of hostilities. 10c.
- CS128. Men's sport shirt sizes — woven fabrics. (Other than those marked with regular neckband sizes). Sept. 20, 1945. 5c.
- CS129. Materials for safety wearing apparel. May 6, 1946. 5c.
- CS130. Color materials for art education in schools. Jan. 1, 1946. 10c.
- CS131. Industrial mineral wool products, all types — testing and reporting. March 15, 1946. 10c.
- CS132. Hardware cloth. April 15, 1946. 5c.
- CS133. Woven-wire netting. June 1, 1946. 5c.
- CS134. Cast aluminum cooking utensils (metal composition). July 20, 1946. 5c.
- CS135. Men's shirt sizes (exclusive of work shirts). July 15, 1946. 5c.
- CS136. Blankets for hospitals (wool, and wool and cotton). Aug. 30, 1946. 5c.
- CS137. Size measurements for men's and boys' shorts — woven fabrics. Dec. 30, 1946. 5c.
- CS138. Insect wire screening. Jan. 2, 1947. 5c.
- CS139. Work gloves. March 6, 1947. 10c.
- CS140. Testing and rating convectors. March 1, 1948. 10c.
- CS141. Sine bars, blocks, plates, and fixtures. Aug. 15, 1947. 5c.

**CS5. Pipe nipples; brass, copper, steel and wrought-iron.**

Covers the detail sizes and dimensions for brass, copper, steel, ferrous-alloy, and wrought-iron pipe nipples; reference to the appropriate Federal and ASTM Specifications controlling the quality of the pipe from which they are made and the threads; chamfering; tolerance on length; standard assortments of lengths for cartons of each size; and a recommended system of labeling to distinguish pipe nipples made according to these standards from those made from crop ends or used pipe. The pamphlet also contains a history of the project, list of acceptors, and the membership of the Standing Committee which is to consider all future revisions prior to circulation for written acceptance. February 15, 1946 (for new production). 5c.



CS13. Dress patterns.

Gives the standard classifications and corresponding body measurements set up by the dress pattern industry as a voluntary basis for dress pattern sizes. It includes for the purposes of this standard a definition of "body measurements." It also gives recommended standard widths of material for pattern layouts. Oct. 20, 1944 (for new production). 5c.

CS14. Boys' button-on waists, shirts, junior and sport shirts.

Gives size designations, methods of measuring, and standard minimum measurements for boys' waists and shirts made of woven fabrics. It also includes a system of button spacing for boys' button-on waists, and a recommended label for use in guaranteeing full size. Aug. 20, 1943 (for new production). 5c.

CS15. Men's pajama sizes — woven fabrics.

Gives size designations, methods of measuring, and standard minimum measurements for men's pajamas, whether made from shrunk or unshrunk woven fabrics, together with a recommended label for guaranteeing conformity to the standard. Jul. 20, 1946 (for new production). 5c.

CS28. Cotton fabric tents, tarpaulins, and covers.

Provides for the marking of treated and untreated finished tents, tarpaulins, and covers, or the fabrics thereof, to show the weight of the fabric in the grey in ounces per square yard; the cut size and the finished size at time of completion of manufacture; the type of fabric; a statement to the effect that canvas products are subject to shrinkage due to variable climatic conditions; and definitions. It requires that no markings or sales descriptions be used to show the finished weight of the fabric which creates confusion in merchandizing. The pamphlet includes a basis and method for marking; the wording of a guarantee statement; nomenclature; definitions; conversion tables; history of the project; and the membership of the Standing Committee. April 15, 1946 (for new production). 5c.

CS33. Knit underwear (exclusive of rayon).

Gives standard methods of measuring and standard measurements set up by the underwear industry as a voluntary basis for the production and purchasing of knit underwear (exclusive of rayon). It also includes recommended box sizes, cone colors for single cotton yarns, and methods of washing. July 30, 1943 (for new production). 20c.

CS35. Hardwood plywood (3d ed.)

Provides minimum specifications for four standard types of hardwood plywood based on the water resistance and durability of the bond, in four standard grades. It covers tests, densities, standard thicknesses, widths and lengths, tolerances, workmanship, packing, inspection, grade-marking and certification, method of ordering, and nomenclature and definitions. Feb. 20, 1947 (for new production). 10c.

CS42. Structural fiber insulating board.

Provides minimum specifications for five classes of structural fiber insulating board known as building board, lath for plaster base, roof insulation board, interior board, and sheathing. It covers physical requirements and tests for thermal conductivity, strength, absorption, and expansion, and sets forth the standard commercial sizes, tolerances, and methods of packing and labeling. Aug. 25, 1943 (for new production). 5c.

CS59. Textiles — testing and reporting (4th ed.).

Records the standard methods of testing and reporting results of tests to determine breaking strength; bursting strength; colorfastness to chlorine, crocking, cleaning (dry and wet), atmospheric gases, laundering, light, perspiration, and pressing (dry and wet); shrinkage in laundering and cleaning; and yarn slippage. They are applicable to textiles composed entirely of cotton, linen, wool, silk or rayon and other synthetic fibers, or mixtures thereof. It also includes the wording of a certificate which may be used on laboratory reports to inform clients that the methods of test and the results thereof are reported in accordance with the requirements of the commercial standard. Feb. 20, 1944 (for testing and reporting). 15c.

CS73. Old growth Douglas fir standard stock doors. (3d ed.)

Provides minimum specifications for four grades of old growth Douglas fir stock doors, made in four thicknesses,  $\frac{3}{4}$ ,  $1\frac{1}{8}$ ,  $1\frac{3}{8}$ , and  $1\frac{3}{4}$  in. It covers construction, dimensions, and grading tolerances for seventy-seven standard stock designs or layouts which include house, garage, and cupboard doors, as well as sidelights. General

requirements for material, workmanship, and construction are set forth, together with provisions for inspection and labeling. Sept. 20, 1945 (for new production). 10c.

CS90E. Power cranes and shovels, convertible full revolving type: crawler, truck and wheel mounted: including clamshell, dragline, lifting crane, hoe, pile driver and skimmer scoop operating equipment (export classifications). (2d ed.)

Covers standard nomenclature and definitions, requirements for stability, propulsion, steering controls, climb and capacity, engineering data to be furnished for purposes of comparison for each machine offered, and shovel sizes of convertible full revolving type crawler, truck and wheel mounted, power cranes and shovels including clamshell, dragline, lifting crane, hoe, pile driver and skimmer scoop for export from the United States of America. It also includes a uniform system of labeling and wording for certificates of compliance with the standard to be furnished with each machine. Feb. 15, 1947 (for new production). 15c.

CS98. Artists' oil paint.

Covers one grade of artists' oil paint and includes criteria of color, nomenclature, chemical composition, working qualities, light-fastness, and performance. Also covers methods of testing to demonstrate conformance with the standard, packaging, and certification of quality. May 10, 1942 (for new production). 5c.

CS99. Gas floor furnaces (gravity circulating type).

Includes definitions, appliance construction requirements, sizing, placement, general installation requirements, venting, and gas connections. It also covers guarantee, certification, and labeling of gravity circulating-type gas floor furnaces. May 25, 1942 (for new production). 5c.

CS100. Porcelain-enameled steel utensils. (2d ed.).

Provides performance requirements for porcelain-enameled steel utensils, both multiple-coated and single-coated, for cooking, household, food storage, and hospital use. The requirements include quality of base metal, appearance, thickness, enameling, resistance to boiling acid, thermal shock, and impact; capacity, methods of test, and labeling. Oct. 25, 1944 (for new production). 10c.

CS101. Flue-connected oil-burning space heaters equipped with vaporizing pot-type burners.

Covers definition, general requirements, design and construction, performance, laboratory test code, and publication of heater ratings. It also covers informative labeling and guarantees on oil-burning space heaters. Jan. 1, 1943 (for new production). 23 p. 10c.

CS102E. Diesel and fuel-oil engines (export classifications).

Covers nomenclature and definitions, ratings, rules for fuel- and lubricating-oil guarantees, standard equipment, lists of spare parts, engine and accessory data, certification, and manufacturers' recommendations on other necessary or desirable equipment for stationary, machine and portable Diesel and fuel-oil engines in export from the United States. Oct. 30, 1942 (for new production). 10c.

CS103. Cotton and rayon velour (jacquard and plain).

Records minimum requirements for width, weights of the pile and the finished fabric, number of pile tufts per square inch, ends of pile and picks per inch, pile coverage, colorfastness to light, anchorage of pile, and abrasion resistance of cotton and rayon velour (jacquard and plain) for upholstery purposes.

The standard also includes methods of test and the manner in which a group of manufacturers are to label their fabrics to inform the purchasers that the quality is in accordance with the requirements of the commercial standard. Nov. 10, 1942 (for new production). 5c.

CS104. Warm-air furnaces equipped with vaporizing pot-type oil burners.

Covers general requirements, furnace design and construction, performance, test codes for forced air and gravity furnaces, publication of furnace ratings, informative labeling, and guarantees. This standard does not include floor furnaces. Oct. 1, 1946 (for new production). 15c.

CS105. Mineral wool; loose, granulated, or felted form, in low-temperature installations.

Covers minimum physical and chemical requirements of loose, granulated, and felted mineral wool for use in insulating low-temperature areas. It includes thickness of insulation required for various operating temperatures, specifications for



auxiliary materials, tests, installation requirements, and method of guarantee compliance with the standard. March 1, 1943 (for new production). 5c.

CS106. Boys' pajama sizes (woven fabrics).

Gives size designations, methods of measuring, and standard minimum measurements for boys' and boys' junior pajamas, whether made from shrunk or unshrunk fabrics, together with a recommended label for use in guaranteeing conformity to the standard. Dec. 9, 1944 (for new production). 5c.

CS107. Commercial electric-refrigeration condensing units.

Covers requirements, rating, motor loading, and testing of air-cooled and water-cooled, belt-driven commercial electric-refrigeration condensing units, in  $\frac{1}{5}$ - to 3-hp sizes, and water-cooled units of 5 hp, using methyl chloride, Freon 12, or SO<sub>2</sub> refrigerants. Covers all other applications, including air conditioning. Covers minimum requirements for controls, shutoff valves and receiver-tank capacities, and also a uniform method of guaranteeing compliance with the standard and installation and service pointers.

CS108. Treading automobile and truck tires.

Covers inspection of the tire to be treaded and the conditions necessary for satisfactory treading, condition of casing and quality of cement used, equipment, workmanship, and guarantee to the purchaser. June 10, 1943. 10c.

CS109. Solid-fuel-burning forced-air furnaces.

Covers surface-fired and magazine feed, solid-fuel-burning warm air furnaces with forced-air circulation in sizes up to 80,000 Btu output, when using chestnut size anthracite as a test fuel.

Sets forth general, construction, and performance requirements, methods of test, data and report sheet, and form of manufacturer's guarantee label. May 10, 1944 (for new production). 10c.

CS110. Tire repairs, vulcanized (passenger, truck, and bus tires).

Covers general requirements for the inspection of the injury to the tire; the minimum acceptable condition of the tire; the method of repair for maximum service; and the recommended wording of a uniform guarantee label. Aug. 20, 1943 (for new production). 5c.

CS111. Earthenware (vitreous glazed) plumbing fixtures.

Covers earthenware (vitreous-glazed) plumbing fixture items such as bath tubs, lavatories, kitchen sinks, laundry trays and similar products. The requirements cover properties of the material, methods of test, method of inspection, grading, definitions, and labeling of items which meet the standard. Oct. 15, 1943 (for new production). 5c.

CS112. Homogenous fiber wallboard.

Provides minimum specifications for one grade of homogenous fiber wallboard of a nominal thickness of  $\frac{5}{16}$  inch, 4 feet wide, and from 6 to 12 feet long. It covers the physical requirements and tests for tensile and transverse strength, deflection, water absorption, and linear expansion, and sets forth the standard commercial sizes, tolerances, and methods of packing and labeling. Oct. 25, 1943 (for new production). 5c.

CS113. Oil-burning floor furnaces equipped with vaporizing pot-type burners.

Covers oil-fired, flue-connected floor furnaces equipped with vaporizing pot-type burners with or without mechanical draft or forced circulation, either manually or automatically controlled. It includes sections on definitions, general requirements, design and construction, performance, laboratory test code, publication of furnace ratings, informative labeling, guarantees, general installation requirements, sizing, placement, and venting. Feb. 17, 1944 (for new production). 10c.

CS114. Hospital sheeting for mattress protection.

Covers fabrics, coating material and workmanship; resistance to mineral oil and disinfectants; resistance to sterilization, accelerated aging and cracking; permeability to water; burning rate; thickness; breaking and tearing strengths; and methods of test. The wording of a guarantee statement by the manufacturer is included. Dec. 1, 1943 (for new production). 5c.

CS116. Bituminized-fibre drain and sewer pipe.

Covers uses, general requirements, dimensions, physical and chemical properties, and methods of testing of bituminized-fibre drain and sewer pipe (including 45° and

90° bends, straight couplings, and 5° angle couplings) in diameters ranging from 2 to 8 inches and in 5- and 8-foot lengths. It also establishes a uniform method of guaranteeing compliance with the standard. Mar. 10, 1944 (for new production). 5c.

CS117. Mineral wool: Blankets, blocks, insulating cement, and pipe insulation for heated industrial equipment.

Covers minimum physical requirements for mineral wool: Blankets, blocks, insulating cement, and pipe insulation for heated industrial equipment. It also covers standard sizes, tolerances, recommended insulation thickness for various operating temperatures, instructions on installation and method of guaranteeing compliance with the standard. May 25, 1944. 10c.

CS118. Marking of jewelry and novelties of silver.

Covers the marking of silver articles commonly or commercially known as jewelry or novelties (other than flatware, hollow ware and toilet ware) offered for sale in the United States.

Also sets forth definitions, quality marks, composition, exemptions, and certification labeling of sterling and coin silver jewelry. August 15, 1944 (for new production). 5c.

CS(E)119. Dial indicators (for linear measurements).

Covers the major essential requirements for precision dial indicators in the American Gage Design type in four groups of sizes, ranging from  $1\frac{3}{8}$  in. to  $3\frac{3}{4}$  in. bezel diameter, with four classes of dial markings in English measure, namely, 0.00005, 0.0001, 0.0005, and 0.001 in., and four classes of dial markings in metric measure, namely, 0.001, 0.002, 0.005, and 0.01 mm. Jan. 1, 1945 (for new production). 5c.

CS120. Standard stock ponderosa pine doors.

Provides minimum specifications for quality and construction of house, garage, cupboard, combination, summer, storm, and toilet doors, and sidelights made of ponderosa pine. Requirements for material, workmanship, sticking, sizes, and grading are set forth, together with illustrations and layouts for 120 different designs. The standard also covers tolerances, inspection, nomenclature and definitions and a method of certifying compliance. October 1, 1946 (for new production). 10c.

CS121. Women's slip sizes (woven fabrics).

Gives standard methods of measuring and standard minimum measurements set up by the women's slip industry on a voluntary basis for the production and purchasing of women's slips (made from woven fabrics). It also includes a recommended label for use in denoting conformity to the standard. April 20, 1945 (for new production). 5c.

CS122. Western hemlock plywood.

Includes general requirements as to workmanship, glueing, veneer thickness, loading, and packing, together with detail specifications for four grades of moisture-resistant-type Western hemlock plywood. There are also included tests for bondage, table of standard sizes, size tolerances, inspection and grade marking provisions, and nomenclature and definitions. March 5, 1945 (for new production). 5c.

CS123. Grading of diamond powder.

Covers grade designations, grain size and size range, amount of "fines" or particles smaller than the minimum for each designation, adulteration and impurities, methods of sampling and inspection, and method of guaranteeing compliance with this standard. May 5, 1945 (for new production). 5c.

CS(E)124. Master disks.

Covers the major essential material and dimensional requirements for master disks in the American Gage Design styles in sizes from above 0.105 in. to and including 8.010 in., as well as specifications for hardness, finish, accuracy tolerances in three classes, and methods of test. It also covers uniform methods of marking, identification, and labeling to guarantee compliance with the standard. Sept. 15, 1945 (for new production). 5c.

CS125. Prefabricated homes.

Provides minimum requirements for one, one and a half, and two story prefabricated homes. It covers structural strength of the various component parts, requirements for light and ventilation, and recommended requirements for foundations, chimneys, heating, plumbing, insulation, and electrical wiring. It includes general requirements for material, workmanship as provided by the manufacturer, erection



at site, and assembly of prefabricated units, and protection during transportation and erection. May 10, 1945 (for new production).

**CS126. Tank mounted air compressors.**

Covers ratings, motor loading, methods of testing single-stage and two-stage air compressors from  $\frac{1}{4}$  horsepower to 10 horsepower, inclusive. It also includes informative labeling. Dec. 5, 1945 (for new production). 10c.

**CS127. Self-contained mechanically refrigerated drinking water coolers.**

Covers definitions, general requirements, methods of testing, method of rating, standard rating conditions, size designations, minimum and maximum capacities, and uniform guarantees of ratings of self-contained mechanically refrigerated drinking water coolers of the insulated storage and instantaneous types, air-cooled or water-cooled, and of certain other listed types and sizes. Effective six months after official announcement of cessation of hostilities. (For new production). 10c.

**CS128. Men's sport shirt sizes — woven fabrics (other than those marked with regular neckband sizes).**

Gives size designations, methods of measuring, and standard minimum measurements for men's sport shirts (other than those marked with regular neckband sizes), whether made from shrunk or unshrunk woven fabrics, together with a recommended label for guaranteeing conformity to the standard. Sept. 20, 1945 (for new production). 5c.

**CS129. Materials for safety wearing apparel.**

Covers asbestos fabrics, flame resistant cotton fabrics, leather, woolen fabrics and accessory materials used in the manufacture of safety wearing apparel. The standard also covers methods of test, and methods of labeling to certify or guarantee quality, together with a list of acceptors, history of the project, and a roster of the Standing Committee. May 6, 1946 (for new production). 5c.

**CS130. Color materials for art education in schools.**

Covers material and workmanship, working qualities, color, packing, methods of test, and quality guarantee for wax and pressed crayons, semi-moist and dry cake water colors, liquid and powder tempera, Type "A" and Type "B" white dustless blackboard crayons, sight saving and colored dustless crayons, molded sight saving, white and colored chalk crayons, lecturers' colored chalk and dustless crayons, pastel crayons, and modeling clay. January 1, 1946 (for new production). 10c.

**CS131. Industrial mineral wool products, all types — testing and reporting.**

Provides uniform methods for testing and reporting the physical and chemical properties of mineral wool products made of rock, slag, or glass and describes equipment required to produce standard results. Methods of test are included for adhesive strength; compressive strength; corrosion resistance; coverage; density; fire resistance; moisture adsorption; odor emission; shot content; temperature stability and thermal conductivity. It also includes the working of a certification which may be used on laboratory reports to inform clients that the method of test and the results thereof are reported in accordance with the requirements of the commercial standard. March 15, 1946 (for testing and reporting). 10c.

**CS132. Hardware cloth.**

Describes the nomenclature, definitions and general requirements for commercial standard hardware cloth designed and woven primarily for use for window guards, screen door guards, tree guards, industrial machinery guards, and other farm and industrial purposes. April 15, 1946 (for new production). 5c.

**CS133. Woven-wire netting.**

Describes the nomenclature, definitions, and general requirements for galvanized steel, woven wire netting designed for use for poultry runs and pens, domestic animal pens, fur-bearing animal pens, trap traps, and stucco reinforcement. June 1, 1946 (for new production). 5c.

**CS134. Cast aluminum cooking utensils (metal composition).**

Covers the composition of the metal and reference to methods of test therefor, of cast aluminum utensils designed and intended for use in the cooking of food. It also includes requirements for marking and labeling to indicate compliance with the standard. July 20, 1946 (for new production). 5c.

CS135. Men's shirt sizes (exclusive of work shirts).

Covers methods of measuring and standard minimum measurements for men's shirts (exclusive of work shirts), together with a recommended label for use in guaranteeing conformity to the standard. July 15, 1946 (for new production). 5c.

CS136. Blankets for hospitals (wool, and wool and cotton).

Covers minimum requirements for all wool, 75 percent wool (cotton warp, wool filling), and 50 percent wool (cotton warp, wool and cotton filling) blankets including for each type the size, weight per square yard, thickness, breaking strength, compressibility, colorfastness, shrinkage and launderability. It also includes methods of test and the recommended working by which manufacturers and distributors may guarantee compliance with the standard. August 30, 1946 (for new production). 5c.

CS137. Size measurements for men's and boys' shorts — woven fabrics.

Gives size designations, methods of measuring, and standard minimum measurements for men's and boys' shorts, together with a recommended label for guaranteeing conformity to the standard. Dec. 30, 1946 (for new production). 5c.

CS138. Insect wire screening.

Describes the nomenclature, definitions and general requirements for commercial standard insect wire screening, designed and woven primarily for installation in or on, any dwelling, building, or structure, for the purpose of preventing the ingress of flies, mosquitoes, or other insects. January 2, 1947 (for new production). 5c.

CS139. Work gloves.

Gives standard definitions, nomenclature, methods of measuring and standard minimum measurements for work gloves, and designates the type of work glove that may be manufactured to the best economic interest of all concerned. It also includes a recommended label for guaranteeing conformity to the standard. March 6, 1947. (for new production). 10c.

CS140. Testing and rating convectors.

Covers definitions, general provisions relative to tests, methods of testing and rating cast-iron and non-ferrous steam and hot water convectors, procedure in obtaining approval of ratings, and method of guaranteeing compliance with the standard. March 1, 1948 (for new production). 10c.

CS141. Sine bars, blocks, plates, and fixtures.

Covers the major essential material and dimensional requirements for sine bars, blocks, plates, and fixtures in all sizes, particularly 5 in., 10 in., and 20 in., and in two accuracy classifications, commercial and laboratory. It also covers definitions of sine bars, blocks, plates and fixtures, and specifications for hardness, finish, accuracy tolerances, and methods of test, as well as uniform methods of marking, identification, and labeling to guarantee compliance with the standard. August 15, 1947 (for new production). 5c.



## BUILDING MATERIALS AND STRUCTURES REPORTS

This series reports the results of Bureau investigations of the properties and suitability of new materials and new methods of construction. The program was carried out with the cooperation and advice of the housing agencies of the Government. The objective was to furnish the Government, the building industry, and the public with technical information that would be useful with particular reference to low-cost housing.

- BMS1. Research on building materials and structures for use in low-cost housing. Hugh L. Dryden. June 16, 1938.
- BMS2. Methods of determining the structural properties of low-cost house constructions. Herbert L. Whittemore and Ambrose H. Stang. Aug. 10, 1938. 10c.
- BMS3. Suitability of fiber insulating lath as a plaster base. Lansing S. Wells and D. C. Smith. Aug. 23, 1938. 15c.
- BMS4. Accelerated aging of fiber building boards. Daniel A. Jessup, Samuel G. Weissberg, and Charles G. Weber. Oct. 11, 1938. 10c.
- BMS5. Structural properties of six masonry wall constructions. Herbert L. Whittemore, Ambrose H. Stang, and Douglas E. Parsons. Nov. 21, 1938. 15c.
- BMS6. Survey of roofing materials in the Southeastern States. Hubert R. Snoke and Leo J. Waldron. Nov. 4, 1938. 15c.
- BMS7. Water permeability of masonry walls. Cyrus C. Fishburn, David Watstein, and Douglas E. Parsons. Oct. 18, 1938. (Superseded by BMS82 and BMS95).
- BMS8. Methods of investigation of surface treatment for corrosion protection of steel. Rolla E. Pollard and Wilbur C. Porter. Oct. 11, 1938. 10c.
- BMS9. Structural properties of the Insulated Steel Construction Co.'s "Frameless-Steel" constructions for walls, partitions, floors, and roofs. Herbert L. Whittemore, Ambrose H. Stang, and Vincent B. Phelan. Oct. 28, 1938. 10c.
- BMS10. Structural properties of one of the "Keystone Beam Steel Floor" constructions sponsored by the H. H. Robertson Co. Herbert L. Whittemore, Ambrose H. Stang, and Cyrus C. Fishburn. Dec. 29, 1938. 10c.
- BMS11. Structural properties of the Curren Fabrihome Corporation's "Fabrihome" constructions for walls and partitions. Herbert L. Whittemore, Ambrose H. Stang, and Vincent B. Phelan. Dec. 28, 1938. 10c.
- BMS12. Structural properties of "Steelox" constructions for walls, partitions, floors, and roofs sponsored by Steel Buildings, Inc. Herbert L. Whittemore, Ambrose H. Stang, and Vincent B. Phelan. Feb. 1, 1939. 15c.
- BMS13. Properties of some fiber building boards of current manufacture. Charles G. Weber and Samuel G. Weissberg. Feb. 23, 1939. 10c.
- BMS14. Indentation and recovery of low-cost floor coverings. P. A. Sigler and Myrtle B. Woodward. Mar. 7, 1939. 10c.
- BMS15. Structural properties of "Wheeling Long-Span Steel Floor" construction sponsored by the Wheeling Corrugating Co. Herbert L. Whittemore, Ambrose H. Stang, and Vincent B. Phelan. Mar. 21, 1939. 10c.
- BMS16. Structural properties of a "Tilecrete" floor construction sponsored by Tilecrete Floors, Inc. Herbert L. Whittemore, Ambrose H. Stang, and Cyrus C. Fishburn. Mar. 24, 1939. 10c.
- BMS17. Sound insulation of wall and floor construction. V. L. Chrisler. Mar. 28, 1939. 20c. Supplement No. 1. Dec. 20, 1940. 5c.  
See page 210 for Supplement No. 2.
- BMS18. Structural properties of "Pre-Fab" constructions for walls, partitions, and floors sponsored by the Harnischfeger Corporation. Herbert L. Whittemore, Ambrose H. Stang, and Vincent B. Phelan. May 17, 1939. 10c.
- BMS19. Preparation and revision of building codes. George N. Thompson. May 1939. 15c.
- BMS20. Structural properties of "Twachtman" constructions for walls and floors sponsored by Connecticut Pre-Cast Buildings Corporation. Herbert L. Whittemore, Ambrose H. Stang, and Douglas E. Parsons. Aug. 17, 1939. 10c.
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- BMS22. Structural properties of "Dun-Ti-Stone" wall construction sponsored by the W. E. Dunn Manufacturing Co. Herbert L. Whittemore, Ambrose H. Stang, and Douglas E. Parsons. Aug. 14, 1939. 10c.
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- BMS26. Structural properties of "Nelson Pre-Cast Concrete Foundation" wall construction sponsored by the Nelson Cement Stone Co., Inc. Herbert L. Whittemore, Ambrose H. Stang, and Cyrus C. Fishburn. Oct. 9, 1939. 10c.
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- BMS36. Structural properties of wood-frame wall, partition, floor, and roof constructions with "Red Stripe" lath sponsored by The Weston Paper and Manufacturing Co. Herbert L. Whittemore and Ambrose H. Stang, with the collaboration of Thomas R. C. Wilson, Forest Products Laboratory. Jan. 2, 1940. 10c.
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- BMS38. Structural properties of two "Dunstone" wall constructions sponsored by the W. E. Dunn Manufacturing Co. Herbert L. Whittemore, Ambrose H. Stang, and Douglas E. Parsons. Feb. 7, 1940. 10c.
- BMS39. Structural properties of a wall construction of "Pfeifer Units" sponsored by the Wisconsin Units Co. Herbert L. Whittemore, Ambrose H. Stang, and Douglas E. Parsons. Jan. 31, 1940. 10c.
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- BMS42. Structural properties of wood-frame wall and partition constructions with "Celotex" insulating boards sponsored by The Celotex Corporation. Herbert L. Whittemore and Ambrose H. Stang, with the collaboration of Thomas R. C. Wilson, Forest Products Laboratory. Mar. 2, 1940. 15c.
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- BMS47. Structural properties of prefabricated wood-frame constructions for walls, partitions, and floors sponsored by American Houses, Inc. Herbert L. Whittemore and Ambrose H. Stang, with the collaboration of Thomas R. C. Wilson, Forest Products Laboratory. June 3, 1940. 20c.
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- BMS58. Strength of soft-soldered joints in copper tubing. Arthur R. Maupin and William H. Swanger. Sept. 20, 1940. 10c.
- BMS59. Properties of adhesives for floor coverings. Percy A. Sigler and Robert I. Martens. Sept. 19, 1940. 10c.
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- BMS61. Structural properties of two nonreinforced monolithic concrete wall constructions. Herbert L. Whittemore, Ambrose H. Stang, and Douglas E. Parsons. Oct. 28, 1940. 10c.
- BMS62. Structural properties of a precast joist concrete floor construction sponsored by the Portland Cement Association. Herbert L. Whittemore, Ambrose H. Stang, and Douglas E. Parsons. Oct. 31, 1940. 10c.
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- BMS65. Methods of estimating loads in plumbing systems. Roy B. Hunter. Dec. 16, 1940. 15c.
- BMS66. Plumbing Manual. Nov. 22, 1940.
- BMS67. Structural properties of "Mu-Steel" prefabricated sheet-steel constructions for walls, partitions, floors, and roofs sponsored by Herman A. Mugler. Herbert L. Whittemore, Ambrose H. Stang, and Vincent B. Phelan. Apr. 12, 1941. 15c.
- BMS68. Performance test of floor coverings for use in low-cost housing: part 3. Percy A. Sigler and Elmer A. Koerner. Jan. 31, 1941. 20c.
- BMS69. Stability of fiber sheathing boards as determined by accelerated aging. Daniel A. Jessup, Charles G. Weber, and Samuel G. Weissberg. Jan. 22, 1941. 10c.
- BMS70. Asphalt, prepared roll roofings and shingles. Hubert R. Snoke. Apr. 10, 1941. 20c.

- BMS71. Fire tests of wood- and metal-framed partitions. S. H. Ingberg and Nolan D. Mitchell. May 12, 1941. 20c.
- BMS72. Structural properties of "Precision-Built, Jr." prefabricated wood-frame wall construction sponsored by the Homasote Co. Archie H. Easton and Mahlon F. Peck, with the collaboration of R. F. Luxford, Forest Products Laboratory. Apr. 14, 1941. 10c.
- BMS73. Indentation characteristics of floor coverings. Percy A. Sigler and Myrtle B. Woodward. Apr. 15, 1941. 10c.
- BMS74. Structural and heat-transfer properties of "U. S. S. Panelbilt" prefabricated sheet-steel constructions for walls, partitions, and roofs sponsored by the Tennessee Coal, Iron & Railroad Co. Herbert L. Whittemore, Ambrose H. Stang, Vincent B. Phelan, and Richard S. Dill. June 30, 1941. 15c.
- BMS75. Survey of roofing materials in the North Central States. Hubert R. Snoke and Leo J. Waldron. July 1, 1941. 15c.
- BMS76. Effect of outdoor exposure on the water permeability of masonry walls. Cyrus C. Fishburn, Douglas E. Parsons, and Perry H. Petersen. Aug. 15, 1941. 15c.
- BMS77. Properties and performance of fiber tile boards. Daniel A. Jessup, Herman Bogaty, and Samuel G. Weissberg. Aug. 8, 1941. 10c.
- BMS78. Structural, heat-transfer, and water-permeability properties of five earth-wall constructions. Herbert L. Whittemore, Ambrose H. Stang, Elbert Hubbell, and Richard S. Dill. Oct. 1, 1941. 25c.
- BMS79. Water-distributing systems for buildings. Roy B. Hunter. Nov. 5, 1941. 20c.
- BMS80. Performance test of floor coverings for use in low-cost housing: part 4. Percy A. Sigler and Elmer A. Koerner. Mar. 2, 1942. 15c.

BMS17. (Supplement No. 2). Sound insulation of wall and floor construction.

This supplement reports the results of sound-transmission measurements made on a number of additional types of construction since the issuance of the original report in March 1939, and the first Supplement issued December 20, 1940. Sept. 15, 1947. 15 p. 10c.

BMS81. Field inspectors' check list for building construction.

Report of Subcommittee on Structure, Central Housing Committee on Research, Design, and Construction

This Check List is intended to be used as a guide and daily reminder to field inspectors on building construction projects. It was prepared by a committee of representatives of Federal agencies active in the building field. In the preparation of the report the committee had the benefit of the experience of its members and consultants, supplemented by data from technical reports.

The list is set up in practical form, in that it outlines the progress of the work by stages rather than by trades. As a result, the inspector can follow the course of erection day by day in its proper sequence without consulting an index to locate information on specific phases of the project. Each successive stage is clearly indicated, and further details on special items are given in the appendices. April 8, 1942. 68 p. 20c.

BMS82. Water permeability of walls built of masonry units. . . . . Cyrus C. Fishburn

The water permeabilities of small masonry wall specimens were measured. Fourteen kinds of workmanship, 39 kinds of units, and 10 kinds of mortars were represented in a group of 140 walls.

The permeability of the specimens was low when the vertical joints were filled or partly filled with mortar or grout, when the suction of the bricks was low, and when a mortar having a high water retentivity was used. The effect of water retentivity of the mortars on the permeability of the walls was greatest when the brick-suction was high. Mortar having a low water retentivity stiffened rapidly when placed in contact with dry, highly absorptive bricks, and units having a low suction floated out of alignment when placed in contact with such a mortar. April 15, 1942. 37 p. 25c.

BMS83. Strength of sleeve joints in copper tubing made with various lead-base solders. . . . . Arthur R. Maupin and William H. Swanger

A previous investigation on soft-soldered sleeve joints in copper tubing for domestic plumbing lines and other uses dealt with joints made with two tin-base solders. To supplement that investigation, the present one on similar joints made with various lead-base solders was conducted. Solders of the following types were used: lead-silver, lead-tin-antimony, lead-cadmium, high lead-low tin, and high-purity lead. Tensile tests at room temperature (short-time tests) were made, together with long-time tests at temperatures ranging from 85° to 325°F. The information from the latter tests is



much more useful than the results of the short-time tests in evaluating soldered joints for service. Consideration must always be given also to possible bond deterioration of the soldered joint at elevated temperatures. On the basis of the results of the first investigation, joints in copper made with tin-base solders were considered satisfactory for general use, provided the temperature did not exceed 250°F. The results of the present study have shown that similar joints made with lead-base tin-free solders can be used with safety at temperatures as high as 325°F. May 5, 1942. 9 p. 10c.

**BMS84. Survey of roofing materials in the South Central States.**

Hubert R. Snoke and Leo J. Waldron

A survey of the weathering qualities and of the extent of use of the various roofing materials on dwellings in the South Central States is described, with numerous references to similar surveys in the Southeastern, Northeastern, and North Central States.

Detailed studies of roofing materials in Chattanooga and Memphis, Tenn.; Jackson, Miss.; New Orleans, La.; Houston, Dallas, San Antonio, and Amarillo, Tex.; Oklahoma City, Okla.; Little Rock, Ark.; and Louisville, Ky., are reported.

A tabulation, by States, of the kinds of roofing materials used on 9,500 rural and small-town dwellings, along approximately 4,200 miles of highway between the cities listed above, is included; also a summary of the kinds of roofing materials used on more than 38,000 rural and small-town dwellings along approximately 11,000 miles of highway in the 37 States covered by the four surveys.

Forty-eight photographs, illustrating the types of weathering of roofing materials, and features of the design and construction of roofs are shown. May 5, 1942. 19 p. 15c.

**BMS85. Dimensional changes of floor coverings with changes in relative humidity and temperature.**

Percy A. Sigler, Robert I. Martens, and Elmer A. Koerner

The effects of changes in atmospheric conditions on the dimensions of floor coverings were investigated. The floor coverings tested included such general types as linoleum, cork, rubber, felt base, asphalt, strip wood, plywood, fiberboard, and several monolithic compositions, such as cement mortar and magnesium oxychloride. Dimensional changes due to a variation in relative humidity from 8 to 86 percent and those due to a variation in temperature from 32° to 90°F were determined. The floor coverings, testing equipment, and procedure are described, and the results are presented in graphic form.

Changes in relative humidity affect the dimensions of many floor coverings to a much greater extent than do changes in temperature within the range usually encountered in structures. Such floor coverings as strip wood, linoleum, and felt show a much greater dimensional change in the across-grain or across machine direction than in the grain or machine direction. The several monolithic compositions showed relatively small changes in dimensions. July 15, 1942. 7 p. 10c.

**BMS86. Structural, heat-transfer, and water-permeability properties of "Speedbrik" wall construction sponsored by the General Shale Products Corporation.**

Mahlon F. Peck, Vincent B. Phelan, Richard S. Dill, and Perry H. Petersen

For the program on the investigation of low-cost house constructions, specimens representing "Speedbrik" masonry wall construction were submitted by the General Shale Products Corporation. These specimens were subjected to structural, heat-transfer, and water-permeability tests.

The structural specimens were subjected to compressive, transverse, concentrated, impact, and racking loads, for each of which three like specimens were tested. The transverse, concentrated, and impact loads were applied to the inside face of the specimens.

The deformation under load and the set after the load was removed were measured for each increment of load.

Heat-transfer properties of two specimens were determined in a shielded hot-box heat-transfer apparatus.

Nine water-permeability specimens were tested under conditions that simulated exposure to a heavy wind-driven rain. July 15, 1942. 17 p. 15c.

**BMS87. A method for developing specifications for building construction.**

Report of Subcommittee on Specifications, Central Housing Committee on Research, Design, and Construction

To meet the demand for short and uniform specifications for Government building construction, and in an attempt to reduce the time and labor now consumed in their

preparation, a representative committee of Federal agencies has made a study of current specification-writing routine. In its report, this committee advocates a directive method which, under proper supervision, should condense specifications, bring about important economies, and increase efficiency.

Fundamental principles that have proved of value over a period of years have been retained, and are coordinated in a basic specification which promotes uniformity and permits choice of those materials and methods of construction best suited to the specific project in hand.

Application of the method is made clear by three examples: a model basic specification illustrating the procedure outlined, a typical contemporary specification, and the typical specification rewritten in accordance with the method advocated. July 15, 1942. 23 p. 15c.

**BMS88.** Recommended building code requirements for new dwelling construction with special reference to war housing.

Report of Subcommittee on Building Codes, Central Housing Committee on Research, Design, and Construction

A series of recommended requirements suitable for use in building codes is presented. The requirements apply to single- and two-family houses and to multiple dwellings of limited height. They cover such matters as fire resistance, light and ventilation, exits, strength of construction, and chimneys and fireplaces. In general, good practice is required, certain well-recognized standards and specifications being cited as acceptable evidence of good practice. Specific dimensions and other details are given where necessary. The report contains an appendix, in which additional information is given, including methods of meeting specific code provisions and references to source material. Sept. 25, 1942. 86 p. Superseded by BMS107.

**BMS89.** Structural properties of "Precision-Built, Jr." (second construction) prefabricated wood-frame wall construction sponsored by the Homasote Co.

W. Gail Hoback, Herman L. Weiss, and Vincent B. Phelan (with the collaboration of the Forest Products Laboratory)

For the program on the determination of the structural properties of low-cost house constructions, the Homasote Co., Trenton, N. J., submitted 18 specimens, representing a wall construction consisting of a wood frame with "Homasote" insulating fiberboard on the inside face and bevel siding on the outside face.

The specimens were subjected to compressive, transverse, concentrated, impact, and racking loads, for each of which three like specimens were tested. The transverse, concentrated, and impact loads were applied to both faces of the specimens.

The deformation under load and the set after the load was removed were measured for each increment of load. The results are presented in graphs and tables. July 17, 1942. 15 p. 15c.

**BMS90.** Structural properties of "PHC" prefabricated wood-frame constructions for walls, floors, and roofs sponsored by the PHC Housing Corporation Mahlon F. Peck, W. Gail Hoback, and Vincent B. Phelan with the collaboration of Carlile P. Winslow, Forest Service

For the program on the determination of the structural properties of low-cost housing, the PHC Housing Corporation submitted 33 specimens representing "PHC" prefabricated wood-frame constructions for walls, floors, and roofs.

The wall specimens were subjected to compressive, transverse, concentrated, impact, and racking loads; the floor specimens to transverse, concentrated, and impact loads; and the roof specimens to transverse and concentrated loads. The transverse, concentrated, and impact loads were applied to both faces of wall specimens. For each of the loads, three like specimens were tested; the concentrated loads were applied to the same specimens as either the transverse or the impact loads. The loads simulated the loads to which the elements of a house are subjected in actual service.

The deformation under load and the set after the load was removed were measured for each increment of load. The results are presented in graphs and tables. August 18, 1942. 34 p. 15c.

**BMS91.** A glossary of housing terms.

Compiled by Subcommittee on Definitions, Central Housing Committee on Research, Design, and Construction

This glossary brings together the various terms used in the field of housing and has been prepared to eliminate the confusion arising from the use of vaguely defined terms or from attributing several meanings to the same term. Whenever possible, definitions have been chosen which are already widely used in codes and statutes. In selecting terms for inclusion in the glossary, reference has been made to building



codes, housing laws, and zoning ordinances, as well as to a large number of standard works. The definitions have been checked with foreign sources, especially "The International Glossary of Housing Terms" published by the International Federation for Housing and Town Planning. A glossary published early in 1937 by a committee from five principal Federal agencies concerned with housing was used as a basis of the present document. Sept. 3, 1942. 32 p. 15c.

BMS92. Fire-resistance classifications of building constructions.

Report of Subcommittee on Fire-Resistance Classifications, Central Housing Committee on Research, Design, and Construction

A classification of building construction from the standpoint of fire safety is presented by a committee of representatives of Federal agencies concerned with the design, construction, and operation of buildings. By considering only the basic properties having a bearing on fire hazard and fire resistance, four types were found sufficient to cover the whole range of building construction. Within each type are two or more classes which are defined by the fire resistance required for their structural members. In chapter I this classification is outlined and information given on how it can be applied with reference to the fire severity obtaining for given structural and occupancy conditions. Chapter II contains a discussion of the types of restrictions and limitations generally incorporated in building codes, with particular reference to their application to the classification of building types herein presented. Chapter III gives results of surveys of combustible contents of buildings housing typical occupancies as a basis for estimating fire severity. In chapter IV are given available fire-resistance ratings of building constructions and fire-resistance classifications of roofing materials. Oct. 7, 1942. 70 p. 30c.

BMS93. Accumulation of moisture in walls of frame construction during winter exposure.....Charles G. Weber and Robert C. Reichel

Data were obtained on the accumulation of moisture in seven types of walls during winter weather. The walls tested were full-height sections in the north outside wall of a frame house on the Bureau grounds. A relatively high humidity was maintained to produce an average drop in vapor pressure across the wall of about 0.2 pound per square inch, which is approximately that produced by an inside relative humidity of 50 percent at about 72°F when the outside temperature is 0°F, or below. Nov. 4, 1942. 5 p. 10c.

BMS94. Water permeability and weathering resistance of stucco-faced gunitel-faced, and "Knap Concrete-Unit" walls.....Cyrus C. Fishburn

The water permeabilities of small stucco, and gunitel-faced walls and of walls built of "Knap concrete units" were measured before and after outdoor weathering. Six kinds of stucco facings, 2 thicknesses of gunitel facings, and 7 kinds of units were represented in a group of 26 walls.

All of the stucco- and gunitel-faced walls were highly resistant to water penetration. Periods of outdoor exposure at Washington, D. C., varying from 16 to 49 months, had no important effect on permeability. The resistance to penetration of walls built of "Knap concrete units" was excellent after the walls were painted. Dec. 2, 1942. 20 p. 10c.

BMS95. Tests of cement-water paints and other waterproofings for unit-masonry walls.....Cyrus C. Fishburn and Douglas E. Parsons

One hundred thirty-one small, highly permeable masonry wall specimens built of concrete blocks or of bricks were treated with cement-water paints or with other waterproofings. The effectiveness of the treatments was measured by comparing the permeability of the walls, before and after treatment, when they were subjected to conditions simulating wind-driven rain. The durability of some treatments was observed by again testing the specimens after they had been weathered outdoors.

The cement-water paints were effective waterproofings and could be applied to the best advantage on the walls of concrete blocks with stiff, rather than soft, brushes. The admixture of fine sand to the paint for the first coat applied to the coarse-textured concrete block increased the effectiveness and durability of the paints. Thick paint films resulting from the application of excessive amounts of paint were effective when first applied, but they were much less durable than thinner coatings. The permeability of the paint films of average thickness was lower after weathering than before.

The colorless waterproofings were generally ineffective. Only one of the colorless waterproofings was satisfactory when first applied, but it was not durable and was much more permeable than the best cement-water paint treatments. The data confirm results previously obtained, which indicate that the only effective and durable method of waterproofing brick walls without changing their appearance was by repointing or grouting of the face joints.

A series of built-in waterproof membranes was an effective waterproofing for brick walls if the leakage through the facing was drained out of the wall through weep holes at the bottom.

The bituminous coatings applied to the inside faces of the walls were ineffective as waterproofings. March 15, 1943. 37 p. 25c.

BMS96. Properties of a porous concrete of cement and uniform-sized gravel.

Perry H. Petersen

The physical properties of a porous concrete consisting solely of portland cement, water, and uniform-sized gravel were investigated. Each of three coarse aggregates, grits (No. 8 to No. 4), pea gravel (No. 4 to  $\frac{3}{8}$  inch), and  $\frac{3}{4}$ -inch gravel ( $\frac{3}{8}$  to  $\frac{3}{4}$  inch), was used, with  $2\frac{1}{2}$  bags of cement per cubic yard in concrete tamped in place and 3 bags per cubic yard when no compacting was done. Walls, wallettes, beams, and bond pull-out specimens were tested, as well as 6- by 12-inch control cylinders. Compressive, transverse, shearing, and bond strengths are reported, as well as resistance to heat transfer, water penetration by capillarity, and rain penetration. March 18, 1943. 15 p. 10c.

BMS97. Experimental dry-wall construction with fiber insulating board.

Charles G. Weber and Robert C. Reichel

The use of fiber insulating boards for the interior surfacing of walls and ceilings of houses has heretofore been limited with respect to choice of design of finish of the walls. The relatively high expansivity of the material with variations in the humidity of the surrounding air has made paneling necessary because molding or batten strips were required to conceal unsightly joints. It was found possible to overcome the difficulty and make paneling unnecessary. This was done by eliminating the usual nailing and substituting the use of invisible, flexible fasteners that permit the entire surface of a wall or ceiling to expand and contract as a unit.

Several methods of fastening the boards to obtain this result were developed. Use of them permitted the successful application of all of the decorative treatments normally applied to a plaster wall, without restriction as to surface design. May 7, 1943. 8 p. 10c.

BMS98. Physical properties of terrazzo aggregates.

Daniel W. Kessler, Arthur Hockman, and Ross E. Anderson

In order to develop basic data for terrazzo specifications, comparative tests were made on 77 marbles used as aggregates. The samples included calcites, dolomites, dolomitic marbles, serpentines, and travertines. Properties studied were abrasive resistance absorption, bulk specific gravity, and toughness of the original rock, and dust content, percentage of voids, and thickness grading of the chips. A few samples were studied for volume changes caused by moisture and temperature.

Flat or elongated chips were found to increase the voids in aggregates, and evidence was found to indicate that the shielding effect of flat chips may interfere with the removal of excess cement paste from mixtures in the rolling operation. May 20, 1943. 19 p. 15c.

BMS99. Structural and heat-transfer properties of "Multiple Box-Girder Plywood Panels" for walls, floors, and roofs sponsored by Loren H. Wittner, Herbert L. Whittemore, Vincent B. Phelan, and Richard S. Dill, with the collaboration of R. F. Luxford, Forest Products Laboratory.

To determine structural and heat-transfer properties, tests were conducted at the request of the War Department on wall, floor, and roof specimens of "Multiple Box-Girder Plywood Panels." The specimens were constructed by gluing and nailing one sheet of plywood between two frames and facing the outer surfaces with other sheets of plywood. The longitudinal and transverse members of the frames with the sheets of plywood formed closed cells, which provided heat insulation.

The wall specimens were subjected to compressive, transverse, concentrated, impact, and racking loads; the floor specimens to transverse, concentrated, and impact loads; and the roof specimens to transverse and concentrated loads. The loads simulated the loads to which the elements are subjected in actual service.

The deformations under load and the sets after the load was removed were measured for uniform increments of load. The results are presented in graphs and tables.

The heat-transfer properties of three wall specimens were determined in a shielded hot-box heat-transfer apparatus. June 11, 1943. 25 p. 15c.

BMS100. Relative slipperiness of floor and deck surfaces.....Percy A. Sigler

A new pendulum-type machine and a method for determining the relative slipperiness of floor surfaces under various conditions are described. The surfaces were tested when dry and clean, dry and dirty, wet and clean, wet and dirty, wet and



soapy, and in a few cases, oily. The results of tests of various floor materials are given, including such general types as stone, terrazzo, cement-mortar, magnesite, ceramic tile, metal, asphalt, rubber, linoleum, and wood. The surfaces of the materials were tested after grinding them with No. 180 silicon carbide. Tests were also made of the original surfaces of many of the materials. The test data show the effect of different wax finishes on the antislip properties of several selected floor materials.

In general, considerable difference in slipperiness was found between dry and wet surfaces. Most of the floor materials showed satisfactory antislip properties when dry. Many would be classed as hazardous when wet. July 1, 1943. 12 p. 10c.

**BMS101. Strength and resistance to corrosion of ties for cavity walls.**

Cyrus C. Fishburn

The resistance to axial loads of ties for cavity walls was determined by testing steel and cement-asbestos ties when they were embedded at the ends in brick masonry. Fourteen different ties and three mortars were represented in a group of about 110 specimens. The ties, with one exception, when spaced one to every 3 ft<sup>2</sup> of wall area, provided connections of ample strength to resist the usual lateral forces to which cavity walls are subjected.

The corrosion resistance of some of the steel ties was measured by exposing them when unprotected and when coated to accelerated and to outdoor weathering. July 1, 1943. 9 p. 10c.

**BMS102. Painting steel.....Wilbur C. Porter**

More than 60 priming paints for plain and galvanized steel surfaces were tested. Because some of these primings were duplicates or near duplicates and others were considered unsuitable, only 41 have been selected for this report. Accelerated laboratory and outdoor exposure tests were employed to determine the relative protective value of these primings when applied to treated and untreated galvanized and plain steel panels. Particularly effective protection against corrosion was observed when primings of the synthetic resin zinc chromate type were used over a phosphate-treated surface. Special attention was given to the effect of pretreating new galvanized steel before painting. More than 2,000 galvanized and plain steel panels were prepared for exposure in the various tests. The relative durability to outdoor exposure of 15 topcoat paints is also discussed. Oct. 16, 1944. 12 p. 10c.

**BMS103. Measurements of heat losses from slab floors.**

Richard S. Dill, William C. Robinson, and Henry E. Robinson

Observations of heat-transfer properties of four concrete floors laid on the ground and three concrete and one wood floor laid over crawl spaces were made in a special structure provided at the National Bureau of Standards for the purpose. This paper gives quantitative information on the results of these observations and suggests some factors for estimating heat losses through floors. March 10, 1945. 21 p. 10c.

**BMS104. Structural properties of prefabricated plywood lightweight construction for walls, partitions, floors, and roofs sponsored by the Douglas Fir Plywood Association.**

Arnold Wexler, Sanford B. Newman, and Vincent B. Phelan

For the program on the determination of structural properties of low-cost house constructions, the Douglas Fir Plywood Association submitted 75 specimens representing prefabricated plywood building panels of both lightweight stress-skin and commercial design. Wall, partition, floor, and roof specimens were of lightweight stress-skin design. Specimens of commercial type panels (2- by 4-in. studs) were for wall construction only, and furnished a basis of comparison of strength and weight with the lightweight constructions.

The wall specimens were subjected to compressive, transverse, concentrated, impact, and racking loads; and the wall specimens of commercial type included three different constructions for determining resistance to racking. The partition specimens were subjected to compressive, transverse, impact, and racking loads; the floor specimens to transverse, concentrated, and impact loads; and the roof specimens to transverse and concentrated loads. The floor and roof specimens included two different constructions for determining resistance to transverse loads. Transverse, concentrated, and impact loads were applied to both faces of wall specimens. The loads simulated the loads to which the elements are subjected in actual service.

The deflection under load and the sets after the load was removed were measured for uniform increments of load. The results are presented in graphs and tables. Nov. 1, 1945. 48 p. 25c.

BMS105. Paint manual: With particular reference to Federal Specifications.

Percy H. Walker and Eugene F. Hickson

The Paint Manual is intended to aid in the interpretation of Federal Specifications relating to paint materials and painting. It contains recommendations by the National Bureau of Standards and cooperating organizations for the most effective use of paint materials whose composition requirements and performance standards are covered in Federal Specifications. Procedures for the preparation of surfaces prior to painting as well as mixing, sampling, inspection, and precautions for safety in the use of paint are suggested and recent developments in the field of painting are explained.

A glossary of selected paint terms and pertinent references are included. October 11, 1945. 165 p. \$1.00.

BMS106. Laboratory observations of condensation in wall specimens.

Richard S. Dill and H. V. Cottony

Tests were made using a wall specimen equipped with eight different arrangements of barriers or seals intended to protect insulation in wall specimens from damage caused by condensation of water vapor. Each arrangement was tested in an apparatus by means of which it was exposed to warm moist air on one side and cold air on the other side so that the effectiveness of the vapor barrier in protecting the insulation and timber from condensation could be observed.

Temperature was closely controlled on both sides of the test specimen and water vapor was generated on the warm side at a rate sufficient to maintain a chosen humidity. Water and frost forming within and on the cold side of the specimen were collected in order to determine its permeability to the passage of water vapor. The importance of a watertight edge seal in obtaining the maximum protection with a vapor barrier was indicated. Aug. 2, 1946. 9 p.

BMS107. Building code requirements for new dwelling construction, recommended by the National Housing Agency and prepared in consultation with the National Bureau of Standards..... George N. Thompson

Recommended minimum requirements for dwelling construction, developed by the National Housing Agency in consultation with the National Bureau of Standards, are presented for consideration by local authorities in revising their building codes. The requirements are based on an earlier publication "Recommended Building Code Requirements for New Dwelling Construction", which has been revised in the light of suggestions from governmental housing agencies, the Forest Products Laboratory, and many industrial organizations. They make free use of national standards, with such additions, modifications, and exceptions as the experience of the housing agencies has demonstrated to be advisable in the case of dwelling construction. An appendix supplies information intended to be helpful in applying and interpreting the provisions of the requirements themselves. Jan. 1, 1947. 43 p. 20c. Supersedes BMS88.

BMS108. Temperature distribution in a test bungalow with various heating devices.

Richard S. Dill and Paul R. Achenbach

The comparative uniformity of temperature distribution attained with various types of heating devices or systems was determined in a test bungalow at the National Bureau of Standards. The heating appliances tested included a hot water heating system, floor furnaces located in several different positions, space heaters with fans, and electric and oil-burning warm-air furnaces. Each heating device was observed under a variety of weather conditions. The conditions inside and the weather outside the laboratory were recorded for comparison. Vertical temperature differences were computed for 32°F outside on the assumption that such differences are proportional to the inside-outside temperature difference. Feb. 28, 1947. 14 p. 10c.

BMS109. Strength of houses: Application of engineering principles to structural design.

Herbert L. Whittemore, John B. Cotter, Ambrose H. Stang, and Vincent B. Phelan.

Methods are here presented for designing small houses to provide adequate strength without waste of material.

For each element of a house, design loads for walls, floors, and roofs — compressive, transverse, and racking — were determined by the accepted principles of engineering mechanics for typical one- and two-story frame houses in several locations representative of extreme wind and snow loads in the United States.

Allowable loads for 100 wall, partition, floor, and roof constructions were obtained by loading large specimens in the laboratory at the National Bureau of Standards. The results of these tests are covered in the "structural properties" reports of the Building



Materials and Structures series. Allowable loads for each of these constructions are compared in this report with design loads for two houses in three locations. The comparison shows that some had insufficient strength while others were much stronger than is necessary. Damage by storm would be negligible and waste of material avoided if houses were designed according to the principles embodied herein. 1948. 132 p. \$1.50.

BMS110. Paints for exterior masonry walls.....Clara Sentel

Results of a series of tests in which four classes of masonry paints (cement-water, resin-emulsion, oil-base, and synthetic-rubber) were applied to test walls of porous masonry, are discussed in this report. The specimens were constructed of new and used common brick; cast concrete; stone-, cinder-, and lightweight aggregate-concrete block; and wood frame with cement-asbestos shingles. The walls were exposed to atmospheric conditions in Washington, D. C., for approximately 3 years.

Formulas for the paints and erection of the wall sections are described, as well as methods of applying paint to the specimens. Ratings based on weathering characteristics of each type of paint and evaluation of painting methods for coating the surfaces are given.

Results of the same tests for a 6-year period are shown graphically in the appendix. Nov. 15, 1947. 19 p. 15c.

## BUILDING AND HOUSING PUBLICATIONS

This series contains reports of investigations and recommended requirements for building and housing. However, the majority of the reports in this series are obsolete and out of print.

- BH1. Recommended minimum requirements for small dwelling construction. 1922.  
(Superseded by BH18).
- BH2. Recommended minimum requirements for plumbing in dwellings and similar buildings. 1923. (Superseded by BH13).
- BH3. A zoning primer. 2d ed. 1926.
- BH4. How to own your home: A handbook for prospective home owners. 1923.  
(Superseded by BH17).
- BH5. A standard state zoning enabling act. 2d ed. 1926.
- BH6. Recommended minimum requirements for masonry wall construction. 1924.  
(Superseded by M174).
- BH7. Minimum live loads allowable for use in design of buildings. 1924.
- BH8. Recommended practice for arrangement of building codes. 1925.
- BH9. Recommended building code requirements for working stresses in building materials. 1926.
- BH10. A city planning primer. 1928.
- BH11. A standard city planning enabling act. 1928.
- BH12. Present home financing methods. 1928.
- BH13. Recommended minimum requirements for plumbing in dwellings and similar buildings. 1928. (Supersedes BH2). 75c.
- BH14. Recommended minimum requirements for fire resistance in buildings. 1930.
- BH15. Care and repair of the house. 1931. 20c.
- BH16. The preparation of zoning ordinances. 1931.
- BH17. How to own your home. 2d ed. 1931. (Supersedes BH4).
- BH18. Recommended minimum requirements for small dwelling construction. 1932.  
(Supersedes BH1).



## MATHEMATICAL TABLES

The tables listed below (with the exception of MT15) were prepared by the Project for the Computation of Mathematical Tables conducted by the Federal Works Agency, Work Projects Administration for the city of New York, under the sponsorship of and made available through the National Bureau of Standards. They are of special interest to physicists, engineers, chemists, biologists, mathematicians, computers, and others engaged in scientific and technical work.

The tables have been arranged in the following groups: Those obtainable from : (1) the Superintendent of Documents, Government Printing Office, (2) Columbia University Press, and (3) those available elsewhere.

### (1) TABLES OBTAINABLE FROM THE SUPERINTENDENT OF DOCUMENTS

- MT1. Table of the first ten powers of the integers from 1 to 1,000.  
 MT2. Tables of the exponential function  $e^x$ . \$3.00.  
 MT3. Tables of circular and hyperbolic sines and cosines for radian arguments. \$2.50.  
 MT4. Tables of sines and cosines for radian arguments. \$2.00.  
 MT5. Tables of sine, cosine, and exponential integrals, volume I. \$2.75.  
 MT6. Tables of sine, cosine, and exponential integrals, volume II. \$2.00.  
 MT7. Table of natural logarithms, volume I. \$3.00.  
 MT8. Tables of probability functions, volume I. \$2.00.  
 MT9. Table of natural logarithms, volume II. \$3.00.  
 MT10. Table of natural logarithms, volume III. \$3.00.  
 MT11. Tables of the moments of inertia and section moduli of ordinary angles, channels, and bulb angles with certain plate combinations. \$2.00.  
 MT12. Table of natural logarithms, volume IV. \$3.00.  
 MT13. Table of sine and cosine integrals for arguments from 10 to 100. \$2.00.  
 MT14. Tables of probability functions, volume II. \$2.25.  
 MT15. The hypergeometric and Legendre functions with applications to integral equations of potential theory. Chester Snow, National Bureau of Standards.  
 MT16. Table of arc tan  $x$ . \$2.00.  
 MT17. Miscellaneous physical tables: Planck's radiation functions, and electronic function. \$1.50.  
 MT18. Table of the zeros of the Legendre polynomials of order 1 — 16 and the weight coefficients for Gauss' mechanical quadrature formula. A. N. Lowan, N. Davids, and A. Levenson. 25c.  
 MT19. On the function  $H(m, a, x) = \text{EXP}(-ix) F(m+1-ia, 2m+2; ix)$ . With table of the confluent hypergeometric function and its first derivative. A. N. Lowan and W. Horenstein. 25c.  
 MT20. Table of integrals  $\int_0^x J_0(t)dt$  and  $\int_0^x Y_0(t)dt$ . Arnold N. Lowan and Milton Abramowitz. 25c.  
 MT21. Table of  $Ji_0(x) = \int_x^\infty \frac{J_0(t)}{t} dt$  and related functions. Arnold N. Lowan, G. Blanch, and M. Abramowitz. 25c.  
 MT22. Table of coefficients in numerical integration formulae. A. N. Lowan and Herbert Salzer.  
 MT23. Table of Fourier coefficients.... Arnold N. Lowan and Jack Laderman  
 Reprinted from Journal of Mathematics and Physics, September 1943. 11 p.  
 MT24. Coefficients for numerical differentiation with central differences.  
 Herbert E. Salzer  
 Reprinted from Journal of Mathematics and Physics, September 1943. 21 p. 25c.  
 MT25. Seven-point Lagrangian integration formulas... G. Blanch and I. Rhodes  
 Reprinted from Journal of Mathematics and Physics, December 1943. 4 p. 25c.  
 MT26. A short table of the first five zeros of the transcendental equation  $J_0(x)Y_0(kx) - J_0(kx)Y_0(x) = 0$ ..... A. N. Lowan and A. Hillman  
 Reprinted from Journal of Mathematics and Physics, December 1943. 2 p. 25c.

- MT27. Table of coefficients for inverse interpolation with central differences.  
Herbert E. Salzer  
Reprinted from Journal of Mathematics and Physics, December 1943. 15 p. 25c.
- MT28. Table of  $f_n(x) = \frac{n!}{(x/2)^n} J_n(x)$ . . . . . The Mathematical Tables Project  
Reprinted from Journal of Mathematics and Physics, February 1944. 16 p. 25c.
- MT29. Table of coefficients for inverse interpolation with advancing differences.  
Herbert E. Salzer  
Reprinted from Journal of Mathematics and Physics, May 1944. 28 p. 25c.
- MT30. A new formula for inverse interpolation. . . . . H. E. Salzer  
Reprinted from Bulletin of the American Mathematical Society, August 1944. 4 p. 25c.
- MT31. Coefficients for interpolation within a square grid in the complex plane.  
A. N. Lowan and H. E. Salzer  
Reprinted from Journal of Mathematics and Physics, August 1944. 11 p. 25c.
- MT32. Table of coefficients for differences in terms of the derivatives. . H. E. Salzer  
Reprinted from Journal of Mathematics and Physics, November 1944. 4 p. 25c.
- MT33. Table of coefficients for numerical integration without differences. .  
A. N. Lowan and H. E. Salzer  
Reprinted from Journal of Mathematics and Physics, February 1945. 21 p. 25c.
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- Table of reciprocals of the integers from 100,000 through 200,009.  
(1943) 201 p. Buckram cover. \$4.00.
- Table of Bessel functions  $J_0(z)$  and  $J_1(z)$  for complex arguments.  
(1943) 403 p. Buckram cover. \$5.00.
- Table of circular and hyperbolic tangents and cotangents for radian arguments.  
(1943) 410 p. Buckram cover. \$5.00.
- Tables of Lagrangian interpolation coefficients.  
(1944) 392 p. Buckram cover. \$5.00.
- Table of arc sin  $x$ .  
(1945) 121 p. Buckram cover. \$3.50.
- Tables of associated Legendre functions.  
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