Publications of the National Bureau of Standards

1966–1967

United States Department of Commerce

National Bureau of Standards

Special Publication 305

UNITED STATES DEPARTMENT OF COMMERCE
MAURICE H. STANS, *Secretary*
NATIONAL BUREAU OF STANDARDS • A. V. Astin, *Director*

Publications of the National Bureau of Standards

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(With Key-word and Author Indexes)

Betty L. Oberholtzer

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U.S. National Bureau of Standards. Special Publication 305
To Accompany National Bureau of Standards Circular 460, its Supplement, Miscellaneous Publication 240, and its Supplement

Issued April 1969

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Preface

This publication represents a significant advance in the efforts of the National Bureau of Standards to mechanize its publication and printing process. While NBS and others have produced a number of publications using computer-generated tapes to drive phototypesetting machines, this is the first NBS publication typeset from magnetic tape generated on a typewriter-like keyboard tied directly to a computer to have the following noteworthy features:

- Mathematical expressions involving subscripts and superscripts are handled without compromise in notation.
- Greek alphabet characters are handled explicitly and may appear on the line, or in superior or inferior positions.
- The information for the key-word and author indexes was extracted from the original input text and permuted by a computer program that also has more general application.
- As an important secondary objective, this printing mechanization has provided magnetic tapes suitable for inclusion in a computerized information system now under development at NBS.

Mechanization in the production of this publication and the computer programs that made it possible are the result of the cooperative efforts of the Data Systems Design Group of the NBS Office of Standard Reference Data and the Computer-Assisted Printing Section of the NBS Office of Technical Information and Publications.

Though many staff members participated in these efforts, I would like to cite the special contributions of Betty Oberholtzer, Rubin Wagner, Rebecca Morehouse, Robert Thompson, and Joseph Hilsenrath.

W. R. TILLEY, *Chief,*
Office of Technical Information
and Publications.

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* Will become Product Standards when revised.

NBS PUBLICATIONS PROGRAM

For many years, the National Bureau of Standards formal publication program has provided a principal and effective means of communicating the results of the Bureau's research, development, and service activities to the scientific and technical community. Publications thus constitute a major end product of the Bureau's efforts, totalling about 1200 items per year. These take the form of the Bureau's four periodicals, its eight nonperiodical publications, and articles in the journals of professional organizations and technological associations.

This book, Publications of the National Bureau of Standards, lists those publications representing the results of the Bureau's in-house programs; the Clearinghouse publications and services are described below.

The Bureau currently publishes four periodicals and eight categories of nonperiodical publications, as listed below:

PERIODICALS

Journal of Research, published in three sections, which are available separately:
- Physics and Chemistry
- Mathematical Sciences (formerly Mathematics and Mathematical Physics)
- Engineering and Instrumentation

Technical News Bulletin

NONPERIODICAL PUBLICATIONS

Monographs, Handbooks, Applied Mathematics Series, National Standard Reference Data Series, Building Science Series, Special Publications (formerly Miscellaneous Publications), Technical Notes, and Product Standards.

PAPERS PUBLISHED BY OTHERS

Many significant contributions by NBS authors are published in other journals. Up-to-date listings of these articles are carried regularly in the Technical News Bulletin, as well as in each section of the Journal of Research, along with selected abstracts.

CLEARINGHOUSE SERVICES

The Clearinghouse for Federal Scientific and Technical Information, operated by NBS, supplies unclassified information related to Government-generated science and technology in defense, space, atomic energy, and other national programs. For further information on Clearinghouse services, write: Clearinghouse, U.S. Department of Commerce, Springfield, Virginia 22151.

1. GENERAL INFORMATION

1.1. PURCHASE PROCEDURES

The publications of the Bureau are available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D. C., 20402, at the prices listed in this publication. You may also order through the U.S. Department of Commerce Field Office nearest you (see page 213 for list of **Field Offices of the U.S. Department of Commerce**). Nonperiodicals (only) may also be ordered through the Clearinghouse for Federal Scientific and Technical Information, National Bureau of Standards, U.S. Department of Commerce, Springfield, Virginia, 22151.

See page 101 for price lists of available publications, plus instructions on how to acquire reprints of articles by NBS authors, and how to get out-of-print material.

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, D. C., 20402, by coupon, postal money order, express money order, or check. Postage stamps will not be accepted. Publications cannot be mailed before remittances are received. *Foreign remittances should be made either by international money order or draft on an American bank.*

The letter symbol, publication number, and full title of the publication must be given when ordering. The Superintendent of Documents allows a discount of 25 percent on orders of 100 or more copies of one publication.

For the convenience of the general public, coupons in the denomination of five cents may be purchased from the Superintendent of Documents. These may be exchanged for Government publications sold by the Superintendent's office. Address order to Superintendent of Documents, U.S. Government Printing Office, Washington, D. C., 20402.

Persons who make frequent purchases from the Superintendent of Documents may find a deposit account convenient. Deposits of $25 or more are accepted against which orders may be placed without making individual remittances or first obtaining quotations. Order blanks are furnished for this purpose. After the order has been processed, the order itself is returned, showing the publications supplied, explanations regarding those not sent, the amount of charge, and the balance on deposit.

No charge is made for postage on documents sent to points in United States and possessions, or to Canada, Mexico, Newfoundland (including Labrador), and certain Central and South American countries. To other countries the regular rate of postage is charged, and remittances must cover such postage. In computing foreign postage, add one-fourth of the price of the publication.

This Special Publication of the National Bureau of Standards lists the publications of the Bureau issued between July 1, 1966 and December 31, 1967. It includes an abstract of each NBS-issued publication; abstracts of papers by Bureau authors appearing in non-NBS journals in 1966 and 1967 (plus some earlier papers omitted from the supplement to Miscellaneous Publication 240); key-word and author indexes; and general information and instructions about NBS publications.

Miscellaneous Publication 240 (covering the period July 1, 1957 through June 30, 1960) and its supplement (covering the period July 1, 1960 through June 30, 1966) remain in effect. Two earlier lists, Circular 460 (Publications of the National Bureau of Standards, 1901 to June 1947) and its supplement (Supplementary List of Publications of the National Bureau of Standards, July 1, 1947 to June 30, 1957) are also still in effect.

The catalogs of NBS publications are more completely described in Section 1.3.

1.2. ANNOUNCEMENTS OF NBS PUBLICATIONS

The Bureau itself does not maintain a free individual mailing list for announcing its new publications. However, the Government agencies mentioned below regularly issue the following official announcements dealing whole or in part with new NBS publications of interest in the journals' respective fields.

Technical News Bulletin. Issued monthly by the National Bureau of Standards. In addition to publishing technical news of the Bureau, the Bulletin announces all new publications by members of the staff, including those appearing in other journals. Available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D. C., 20402. Annual subscription, $3.00; $4.00 foreign. Single copies, 15 cents each (see also Sections 2.2 and 2.3).

Monthly Catalog of United States Government Publications. Issued monthly by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C., 20402. Annual subscription, with consolidated annual index, $6.00; $7.50 foreign.

Price Lists. These consist of lists of publications prepared by the Superintendent of Documents on special subjects. Single copies sent on request without charge provided you state the subject matter field in which you desire information. For a complete List and order form for subject price lists, request a copy of **How to Keep in Touch with United States Government**

Publications from the Superintendent of Documents, U.S. Government Printing Office, Washington, D. C., 20402.

List of Selected Government Publications. Issued semimonthly by the Superintendent of Documents. Each list is arranged alphabetically by subjects, with annotations and prices. May be obtained free from that office.

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 $2.50 a year domestic; $5.50 foreign.

1.3. CATALOGS OF NBS PUBLICATIONS

Previous catalogs, plus this publication, constitute a complete list of the titles of the Bureau's publication through December 31, 1967, including brief abstracts of the material published in the NBS publication series. This publication also contains abstracts of papers published recently in outside media. Where the price is given, the catalog is available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D. C., 20402. Otherwise, it may be consulted in a library which maintains sets of National Bureau of Standards publications.

Circular 24, 7th edition: Publications of the Bureau of Standards 1901 to 1925. 271 pages, including brief abstracts and subject index	(*)
Circular 24 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	(*)
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	(*)
Circular 460: Publications of the National Bureau of Standards 1901 to June 30, 1947. 375 pages, including subject and author indexes. Brief abstracts are included for the period January 1, 1941, to June 30, 1947	$1.25
Supplement to Circular 460, Publications of the National Bureau of Standards, July 1, 1947, to June 30, 1957. 373 pages, including subject and author indexes	$1.50
Miscellaneous Publication 240: Publications of the National Bureau of Standards July 1, 1957, to June 30, 1960. Includes Titles of Papers Published in Outside Journals 1950 to 1959. 391 pages, including subject and author indexes	$2.25
Supplement to Miscellaneous Publication 240, Publications of the National Bureau of Standards published by NBS, July 1960 through June 1966; published by Others, 1960 through 1965. 740 pages, including subject and author indexes	$4.00
Special Publication 305, Publications of the National Bureau of Standards published by NBS, July 1966 through December 1967; published by others, 1966-1967. 213 pages including subject and author indexes	$2.00

1.4. DEPOSITORY LIBRARIES IN THE UNITED STATES

The Superintendent of Documents, United States Government Printing Office, is authorized by law to furnish Government publications to designated depository libraries. The libraries listed in Appendix A are now receiving selected publication series of the National Bureau of Standards for general reference use. Whether a given library has a copy of a particular publication can be determined by inquiring at the library.

1.5. FIELD OFFICES OF THE U.S. DEPARTMENT OF COMMERCE

Department of Commerce Field Offices are maintained in the cities listed in Appendix B. Their purpose is to provide ready access, at the local level, to the Department's reports, publications, statistical statements, surveys, as well as to the specialized and experienced staff in charge. Each Field Office serves as an official sales agent of the Superintendent of Documents, U.S. Government Printing Office, making available for purchase locally a wide range of Government publications. The reference library maintained by each Field Office contains many Government and private publications, periodicals, directories, reports, and other reference materials.

2. DESCRIPTION OF NBS PERIODICALS AND NONPERIODICALS

2.1. JOURNAL OF RESEARCH

The *Journal of Research* reports research and development in physics, mathematics, chemistry, and engineering. Comprehensive scientific papers give complete details of the work, including laboratory data, experimental procedures, and theoretical and mathematical analyses. The *Journal* also presents review articles by recognized authorities and compilations of information on subjects closely related to the Bureau's technical program. The *Journal of Research* is issued in three separate sections as follows:

A. Physics and Chemistry

This section presents papers of interest primarily to scientists working in these fields. It covers a broad range of physical and chemi-

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* Out of print.

cal research, with major emphasis on standards of physical measurements, fundamental constants and properties of matter. Issued six times a year.

Editor: C. W. Beckett
Associate Editor: D. D. Wagman

B. *Mathematical Sciences*

This section presents studies and compilations designed mainly for the mathematician and theoretical physicist. Topics in mathematical statistics, theory of experiment design, numerical analysis, theoretical physics and chemistry, logical design and programming of computers and computer systems are covered, together with short numerical tables. Issued quarterly.

Editor: M. Newman
Associate Editors: J. J. Sopka, F. W. Olver, and J. R. Edmonds

C. *Engineering and Instrumentation*

This section reports results of interest chiefly to the engineer and the applied scientist. It includes many of the new developments in instrumentation resulting from the Bureau's work in physical measurement, data processing, and development of test methods. It also covers some of the work in acoustics, applied mechanics, building research, and cryogenic engineering. Issued quarterly.

Editor: M. Greenspan
Associate Editors: G. F. Montgomery, R. V. Smith, and A. F. Schmidt

2.2. TECHNICAL NEWS BULLETIN

Reports results of Bureau's programs in measurement standards and techniques, properties of matter and materials, engineering standards and services, instrumentation, and automatic data processing.

The best single source of information concerning the Bureau's research, developmental, cooperative and publication activities, this monthly publication is designed for the industry-oriented individual whose daily work involves intimate contact with science and technology—engineers, chemists, physicists, research managers, product-development managers, and company executives. Readers use the *TNB* to learn of new developments with practical applications, to fill in background, to get ideas for further investigations, and for information on NBS calibration services and publications. Issued monthly.

2.3. PERIODICAL SUBSCRIPTION RATES

Periodical	Domestic[1]	Foreign[2]
Journal of Research of the National Bureau of Standards:		
Section A. Physics and Chemistry, issued six times a year, paper covers (4)	$6.00	$7.25
Bound volume (1 volume per year), blue buckram	(3)	(3)
Section B. Mathematics and Mathematical Physics, issued quarterly, paper covers	2.25	2.75
Bound volume (1 volume per year), green buckham (4)	(3)	(3)
Section C. Engineering and Instrumentation, issued quarterly, paper covers	2.75	3.50
Bound volume (1 volume per year), salmon buckram (4)	(3)	(3)
Technical News Bulletin, 12 monthly issues (4)	3.00	4.00

NOTE.—Send order, with remittance, to Superintendent of Documents, U.S. Government Printing Office, Washington, D. C. 20402.

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[1] United States and its possessions, Canada, Mexico, Newfoundland (including Laborador), and certain Central and South American countries.

[2] Foreign price includes the cost of the publication and postage.

[3] Prices of the bound volumes vary. The Superintendent of Documents will furnish prices on request.

[4] These monthly periodicals may be obtained on a 1-, 2-, or 3-year subscription basis (although at no reduction in rates).

2.4. NONPERIODICALS

Eight categories of nonperiodical publications, as described below, are listed in this catalog:

MONOGRAPHS—major contributions to the technical literature on various subjects related to the Bureau's scientific and technical activities.

HANDBOOKS—recommended codes of engineering and industrial practice (including safety codes) developed in cooperation with interested industries, professional organizations, and regulatory bodies.

MISCELLANEOUS PUBLICATIONS—This series provides material of a particular nature and quality. It includes proceedings of high-level national and international conferences sponsored by NBS, precision measurement and calibration volumes, NBS Research Highlights, and other special publications appropriate to this grouping. This series has been redesignated Special Publications.

APPLIED MATHEMATICS SERIES—mathematical tables, manuals, and studies.

NATIONAL STANDARD REFERENCE DATA SERIES—provides quantitative data on the physical and chemical properties of materials, compiled from the world's literature and critically evaluated. Developed under a worldwide program coordinated by NBS.

BUILDING SCIENCE SERIES—research results, test methods, and performance criteria of building materials, components, systems, and structures.

TECHNICAL NOTES—designed to supplement the Bureau's regular publications program. Communications and reports of data of limited or transitory interest. Often serve as final reports on work sponsored at NBS by other Government agencies.

PRODUCT STANDARDS—developed cooperatively with interested Government and industry groups, and used voluntarily. The term *Product Standards* is now being used to identify all new standards as well as all revisions of existing standards. Existing standards will continue to be referred to as *Commercial Standards* or *Simplified Practice Recommendations* until such time as they are revised.

3. TITLES AND ABSTRACTS OF NBS PUBLICATIONS

The letter designations shown are used to indicate the various NBS nonperiodical publications. These letter designations should be used, along with the series number and title, when ordering or inquiring about NBS nonperiodical publications.

Mono	Monographs
H	Handbooks
M	Miscellaneous Publications *
AMS	Applied Mathematics Series
NSRDS	National Standard Reference Data Series
BSS	Building Science Series
PS	Product Standards
CS	Commercial Standards **
SPR	Simplified Practice Recommendations **
TN	Technical Notes

When ordering, or inquiring about, *reprints from the Journal of Research*, you should not only use the J and A, B, or C (explained below), but should also consult either the author or the key-word index (as appropriate) and use the volume, section, issue, paper, and page number which you find there. For example, if you wish to order or inquire about "Electric Fields Produced in Cubic Crystals by Point Defects", by A. D. Franklin and D. J. Sparks, you should use this designation: *J* **71A** 1-428, 1-2 (1967).

(For an explanation of the volume-section-issue-paper-and-page number symbol, see table B on page 112).

J, Journal of Research:
- A. Physics and Chemistry
- B. Mathematics and Mathematical Physics
- C. Engineering and Instrumentation

Prices of publications are listed on page 101.

Other details about ordering, including information about reprints of material by NBS authors and out-of-print material, are also included in that section.

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* Redesignated "Special Publications" as of January 1968.
** Will become "Product Standards" when revised.

3.1. PAPERS FROM THE JOURNAL OF RESEARCH OF THE NATIONAL BUREAU OF STANDARDS, SECTION A. PHYSICS AND CHEMISTRY, VOLUME 70A, JULY–DECEMBER 1966

July-August 1966

Elastic constants of synthetic single crystal corundum, W. E. Tefft, *J. Res. NBS* 70A4-403, pp. 277-280 (July-Aug. 1966).

> Key words: Aluminum oxide; corundum; elastic constants; shear modulus; Young's modulus.

The elastic constants of synthetic single crystal corundum (aluminum oxide) were calculated from 0 to 900 °K from data obtained by a resonance technique from 80 to 900 °K.

Phase equilibria as related to crystal structure in the system niobium pentoxide-tungsten trioxide, R. S. Roth and J. L. Waring, *J. Res. NBS* 70A4-404, pp. 281-303 (July-Aug. 1966).

> Key words: Crystal structure; niobium pentoxide; phase equilibria; system; tungsten trioxide.

The phase equilibrium diagram for the binary system niobium pentoxide-tungsten trioxide has been constructed from results of x-ray diffraction studies on both single crystals and powders and from fusion characteristics. Twelve stable compounds have been found in the system. The exact composition of eight of these compounds has been established by single crystal analyses at the Nb_2O_5:WO_3 ratios of 6:1, 13:4, 7:3, 8:5, 9:8, 1:1, 4:9, and 2:7. The approximate compositions of the remaining four other phases are 30:1, 6:11, 1:11, and 1:15. The 6:1, "6:11", 4:9, and 2:7 phases melt congruently at 1476, 1378, 1380, and 1357 °C, respectively. The "30:1", 7:3, 8:5, 9:8, "1:11", and "1:15" phases melt incongruently at 1470, 1440, 1385, 1375, 1356, and 1358 °C, respectively; and the 13:4 and 1:1 phases decompose before melting at 1435 and 1115 °C, respectively. The 8:5, 9:8, "6:11", 2:7, "1:11", and "1:15" compounds are shown on the phase diagram as having minimum temperatures of stability. One metastable phase having a narrow range of composition near the 3:8 ratio was also encountered. Although Nb_2O_5 apparently exhibits no solid solution, WO_3 was found to accept a maximum of three mole percent niobia in solid solution enabling all the reported polymorphs of WO_3 to be obtained at room temperature.

Properties of aqueous mixtures of pure salts. Thermodynamics of the ternary system: Water-calcium chloride-magnesium chloride at 25 °C, R. A. Robinson and V. E. Bower, *J. Res. NBS* 70A4-405, pp. 305-311 (July-Aug. 1966).

> Key words: Isopiestic measurements; vapor pressure; calcium chloride; mixed solutions; activity coefficients.

Isopiestic vapor pressure measurements have been made on the system water-calcium chloride-magnesium chloride at 25 °C. Activity coefficients have been evaluated for each salt in the presence of the other in systems of constant total ionic strength. The excess free energy of mixing has been calculated and compared with the values for analogous systems.

Properties of aqueous mixtures of pure salts. Thermodynamics of the ternary system: Water-sodium chloride-calcium chloride at 25 °C, R. A. Robinson and V. E. Bower, *J. Res. NBS* 70A4-406, pp. 313-318 (July-Aug. 1966).

> Key words: Calcium chloride; isopiestic measurements; mixed salt solutions; sodium chloride; vapor pressure of aqueous solutions.

Isopiestic vapor pressure measurements have been made to determine some thermodynamic properties of the system: water-sodium chloride-calcium chloride at 25 °C. Equations are derived for the activity coefficient of each salt in the presence of the other when the total ionic strength is kept constant. The limiting conditions in very dilute solutions are considered and "trace" activity coefficients calculated. A comparison with previous work is made. The excess free energy of mixing is calculated.

Use of the consistency check in the vector verification method, A. D. Mighell and R. A. Jacobson, *J. Res. NBS* 70A4-407, pp. 319-321 (July-Aug. 1966).

> Key words: Crystal; structure; Patterson; vector; symmetry; consistency; frequency; superposition.

The consistency check is a type of frequency check in which full use is made of the space group symmetry. It is designed for application to a symmetry map, to a tentative atom map, to the results of superpositions, or to any pseudoelectron-density map. Like the frequency check, its purpose is to aid in the analysis of one of the above maps by assigning a relative weight (relative weight equals the number of other peaks that the given peak is consistent with) to the peaks in these maps. To determine the relative weight, each peak in the map is compared with each of the others to see if it is consistent. Two peaks are considered consistent with each other, if and only if, the set of unique vectors between the two is present in the Patterson map. The method is equivalent to doing a full set of symmetry superpositions at each peak in a symmetry map or a tentative atom map; counting the number of points in the resulting map; and outputting this number at the initial peak position. No assumptions other than that for space group symmetry are required to apply the consistency check to a symmetry map. The resulting map, which has been calculated in a routine fashion directly from the Patterson map, may then be conveniently used as the starting point for the structure analysis of an unknown compound.

Self-reversal in the spectral lines of uranium, D. D. Laun, *J. Res. NBS* 70A4-408, pp. 323-324 (July-Aug. 1966).

> Key words: Uranium, spectrum; spectrum, uranium; self-reversal; uranium spectrum.

In 1946, spectrum analysis indicated that the outer-electron configuration of normal uranium atoms was $5f^36d^17s^2$, with an energy level designated $^5L^\circ_6$ representing the normal state. Now that conclusion is experimentally verified by the observation of self-reversed lines in uranium spectra emitted by a high-current pulsed arc between metallic electrodes. Fifty-four reversed lines were observed; thirty-eight involve the normal state and sixteen are distributed among four low metastable states of the same configuration.

Oscillator strengths for ultraviolet lines of Fe I, C. H. Corliss and B. Warner, *J. Res. NBS* 70A4-409, pp. 325-371 (July-Aug. 1966).

> Key words: Atomic spectra; iron; oscillator strengths; transition probability; ultraviolet lines of Fe I.

Relative intensities and oscillator strengths for 2000 ultraviolet lines of Fe I from several investigations between 2080 and 4150 Å have been critically discussed and adjusted to a uniform absolute scale. New values for many lines not measured heretofore are reported.

September-October 1966

Orientation of calcium molybdate ($CaMoO_4$) and other single crystals having the scheelite structure, E. N. Farabaugh, H. S. Peiser, and J. B. Wachtman, Jr., *J. Res. NBS* **70A5-410**, pp. 379-384 (Sept.-Oct. 1966).

Key words: Calcium molybdate; crystal orientation; crystallographic groups; interplanar angles; physical properties; scheelite structure; single crystal; x-ray back-reflection.

Values of interplanar angles useful in distinguishing the [100] from the [110] direction in $CaMoO_4$ are given to facilitate orientation by analysis of back-reflection Laue patterns. The distinction between the [001] and [001] directions in the scheelite structure is discussed and examples of physical properties dependent upon this distinction are given. The [001] direction is defined in terms of the crystal structure and a procedure for identifying (001) using Laue patterns is described. The same distinction applies to certain nonpolar directions of all crystals belonging to the following nonenantiomorphous point groups: $\bar{1}$, m, 2/m, mmm, $\bar{3}$, 3m, $\bar{3}$m, $\bar{4}$, 4/m, 4/mmm, $\bar{6}$, 6/m, 6/mmm, m3, and m3m.

Crystal structure of $BaGe[Ge_3O_9]$ and its relation to benitoite, C. Robbins, A. Perloff, and S. Block, *J. Res. NBS* **70A5-411**, pp. 385-391 (Sept.-Oct. 1966).

Key words: Barium tetragermanate; structure; benitoite; crystal; x-ray.

$BaGe[Ge_3O_9]$ is trigonal space group P3 with lattice constants $a=11.61$, $c=4.74$ Å, and $Z=3$. The structure was established by three-dimensional Patterson and electron density syntheses. Three-dimensional least-squares refinement resulted in a final R value of 6.8 percent (observed data only).

The previously proposed structural relationship of this compound with benitoite, $BaTiSi_3O_9$, has been confirmed. The structure can be considered as composed of Ge_3O_9 rings, in which the Ge is tetrahedrally coordinated, linked through octahedrally coordinated Ge atoms to form a three-dimensional Ge-O network. All Ge polyhedra are linked by corner sharing. The Ba ions occupy positions in channels of the network.

A rotating cylinder method for measuring normal spectral emittance of ceramic oxide specimens from 1200 to 1600 °K, H. E. Clark and D. G. Moore, *J. Res. NBS* **70A5-412**, pp. 393-415 (Sept.-Oct. 1966).

Key words: Alumina; ceramic oxides; emittance; error sources; magnesia; measurement uncertainties; spectral emittance; thermal radiation; thoria; zirconia.

Equipment was designed and constructed for measuring the spectral emittance of polycrystalline ceramic oxide specimens in the wavelength region 1 to 15 μ and at temperatures of 1200, 1400, and 1600 °K. Specimens consisted of small hollow cylinders that were rotated at 100 rpm in a furnace cavity equipped with a water-cooled viewing port. Emittances were determined by comparing the radiance of the specimen to that of a blackbody at the same temperature.

A series of six measurements (two measurements each on three specimens) was made on commercially pure specimens of alumina, thoria, magnesia, and zirconia. All four materials showed similar behavior in that the emittances were low in the shorter wavelength regions and high at the longer wavelengths. The temperature coefficients of spectral emittance were positive for all four materials, but varied with the material; those for thoria were appreciably higher than the other three. In all cases coefficients were greater at short wavelengths than at long.

Error sources were investigated, and the measurement uncertainties associated with each source were evaluated. It was concluded that at 1200 °K the true values of emittance at 2 μ for the particular specimens measured might be as much as 0.032 lower or 0.012 higher than the reported values. The data were in good agreement with reflectance measurements of the same material and with recently reported absorption coefficients.

Electron absorption spectrum of cobalt(II)-doped trisphenanthrolinezinc nitrate dihydrate, C.W. Reimann, *J. Res. NBS* **70A5-413**, pp. 417-419 (Sept.-Oct. 1966).

Key words: Trisphenanthroline cobalt(II) nitrate dihydrate; trisphenanthrolinezinc nitrate dihydrate; electron absorption spectrum.

The electron absorption spectrum of cobalt(II)-doped trisphenanthrolinezinc nitrate dihydrate has been observed at room temperature and at 77 °K. Broad bands appear at 10,750 and 22,000 cm^{-1} which are assigned to the ${}^4T_{1g}(F) \longleftrightarrow {}^4T_{2g}(F)$ and the ${}^4T_{1g}(F) \longleftrightarrow {}^4T_{1g}(P)$ transitions respectively. A broad weak band occurs near 19,000 cm^{-1} but at 77 °K this band is resolved into a series of narrower bands. These bands are assigned to ${}^2G$ transitions. The relationship between the spectrum of cobalt(II) trisphenanthrolinezinc nitrate dihydrate and the solution spectra of cobalt(II) in ammonia and ethylenediamine is discussed.

Procedures for homogeneous anionic polymerization, L. J. Fetters, *J. Res. NBS* **70A5-414**, pp. 421-433 (Sept.-Oct. 1966).

Key words: Homogeneous anionic polymerization; monodisperse, polystyrene, poly-α-methylstyrene; polyisoprene; and polybutadiene.

This report is a review of the procedures and equipment used in the preparation of polymers of predictable molecular weights and narrow molecular weight distributions. The monomers considered in detail are sytrene, α-methylstyrene, isoprene, and butadiene.

The configurations $4d^n+4d^{n-1}\,5s$ in doubly-ionized atoms of the palladium group, Y. Shadmi, *J. Res. NBS* **70A5-415**, pp. 435-445 (Sept.-Oct. 1966).

Key words: Configurations $4d^n+4d^{n-1}\,5s$, energy levels; interaction parameters; palladium group; theoretical; third spectra.

Four hundred and eighty-three energy levels belonging to the low even configurations of the third spectra of the palladium group are predicted by the use of interpolation formulas for the interaction parameters.

November-December 1966

Absolute isotopic abundance ratios and atomic weight of magnesium, E. J. Catanzaro, T. J. Murphy, E. L. Garner, and W. R. Shields, *J. Res. NBS* **70A6-416**, pp. 453-458 (Nov.-Dec. 1966).

Key words: Absolute ratios; atomic weight; isotopic abundances; magnesium.

Absolute values have been obtained for the isotopic abundance ratios of magnesium, using surface emission mass spectrometry. Samples of known isotopic composition, prepared from nearly pure separated magnesium isotopes, were used to calibrate the mass spectrometers. The resulting absolute values are $^{25}Mg/^{24}Mg = 0.12663 \pm 0.00013$ and $^{26}Mg/^{24}Mg = 0.13932 \pm 0.00026$, yielding an atomic weight ($^{12}C = 12$) of 24.30497 ± 0.00044. The indicated uncertainties are overall limits of error based on 95 percent confidence limits for the mean and allowances for effects of known sources of possible systematic error.

Mass spectrometric study of photoionization, V. Water and ammonia, V. H. Dibeler, J. A. Walker, and H. M. Rosenstock, *J. Res. NBS* **70A6-417**, pp. 459-463 (Nov.-Dec. 1966).

> Key words: Autoionization; electronic; excited states; H_2O^+; NH_3^+; NH_2^+; OH^+ ions; heats of formation; ionization thresholds; mass spectrometer; photoionization; radicals; Rydberg levels; vacuum monochromators.

Photoionization efficiency curves are obtained for the molecule and fragment ions of H_2O and NH_3 in the wavelength region extending from onset of ionization to 600 A. Threshold values of 12.593eV and 10.162eV are observed for the H_2O^+ and NH_3^+ ions, respectively. Vibrationally excited states of the molecule ions and autoionization of Rydberg levels are observed. A determination of the bond angle of the H_2O^+ ion from the Franck-Condon factors of the bending overtones results in a value of 112 degrees. Threshold values of the fragment ions permit calculations of heats of formation of the OH^+ and NH_2^+ ions and result in the ionization energies, $I(OH)=12.94eV$ and $I(NH_2)=11.22eV$.

Interpretation of the third spectrum of gold (Au III), L. Iglesias, *J. Res. NBS* **70A6-418**, pp. 465-466 (Nov.-Dec. 1966).

> Key words: Corrections to analysis of Au III; gold; spectrum of Au III; third spectrum.

A revision of the analysis of the Au III spectrum is presented. Of 9 energy levels considered doubtful on the basis of a recent theoretical treatment, 6 are found to be real and 3 have been rejected as incorrect. Three new energy levels have also been found in agreement with theoretical predictions.

A formal solution for slit corrections in small-angle x-ray scattering, J. Mazur and A. M. Wims, *J. Res. NBS* **70A6-419**, pp. 467-471 (Nov.-Dec. 1966).

> Key words: Distribution of intensity; integral equation; scattering cross section; slit correction; small-angle x-ray scattering.

Slit shaped apertures are usually used in small-angle x-ray scattering measurements in order to obtain easily measured intensities of scattered radiation. As a result, the scattering intensity at a given angle determined by the camera, the center of the sample, and the central incident x-ray beam is not simply related to the scattering from the sample only at that angle. The experimentally determined intensities $I(x)$ are related to the true scattering intensities by the following integral equation:

$$\tilde{I}(x) = \int_{-\infty}^{\infty} I[(x^2+t^2)^{1/2}]W(t)dt.$$

This integral equation has been previously solved only for certain simplified functional forms for $W(t)$ and $I(x)$. In this paper, a formal procedure is developed for calculating $I(x)$ from the observed angular measurements, which does not necessitate making any a priori assumption about the form of $W(t)$ and $I(x)$.

High-temperature reactions of hexafluorobenzene, J. M. Antonucci and L. A. Wall, *J. Res. NBS* **70A6-420**, pp. 473-480 (Nov.-Dec. 1966).

> Key words: Direct replacement; high temperature; mechanisms; nonionic or ionic coreactants; nuclear fluorine; pentafluorohalobenzenes.

The direct replacement of aromatic fluorine in hexafluorobenzene has hitherto been possible only by the use of nucleophilic reagents. In this investigation, the replacement of nuclear fluorine by nonnucleophilic, or weakly nucleophilic, reagents was achieved by reaction at relatively high temperatures, 300 to 850 °C. For example, the reaction of hexafluorobenzene with such reagents as bromine, chlorine, and tetrafluoroethylene gave as major products bromopentafluorobenezene, chloropentafluorobenzene, and octafluorotoluene. In addition, pentafluorohalobenzenes can also be produced by passage of hexafluorobenzene over the appropriate alkali or alkaline earth-metal halides at elevated temperatures.

The mechanism of the pyrolytic reactions of hexafluorobenzene and the nonionic coreactants are considered to involve free-radical intermediates. The reaction of hexafluorobenzene with the ionic coreactants may proceed by an ionic mechanism similar to that advanced for the usual, relatively low temperature, nucleophilic substitution reactions of aromatic systems. However, a more complicated free radical-ionic process cannot be ruled out for these reactions.

The melting temperatures of the *n*-paraffins and the convergence temperature for polyethylene, M. G. Broadhurst, *J. Res. NBS* **70A6-421**, pp. 481-486 (Nov.-Dec. 1966).

> Key words: Convergence temperature; melting temperatures; methyl surfaces; *n*-paraffins; polyethylene; thermodynamic properties.

The extrapolation of the melting points, T_m, of the *n*-paraffins to large chain lengths ($n \to \infty$) is reexamined in order to resolve the differences in the proposed values of the convergence temperature $T_0 = \lim_{n\to\infty} T_m$. Experimental liquid entropies can be made consistent with a term, $R \ln n$, proposed by Flory and Vrij. This term effectively replaces the well-known expression $T_m = T_0(n+a)/(n+b)$ with an expression $T_m = T_0(n+a)/(n+\ln n+b)$; thus, slowing the convergence rate and increasing T_0 from 141.1 °C to 144.7 °C. Independent estimates of the parameters in the melting relationship were obtained from thermodynamic data and the least squares estimate of $T_0=144.7$ °C (calculated from 33 melting points with a standard deviation of $T_m=0.3$ °C) could not be altered by more than ±0.5 °C by any reasonable variation of the parameters. A simplified melting expression is obtained for polyethylene which includes both the chain end and fold surface energies, and it is shown that chain end effects partly account for the discrepancy between the 144.7 °C convergence temperature and experimental melting temperatures (~139 °C) of extended chain polyethylene crystals.

General treatment of the thermogravimetry of polymers, J. H. Flynn and L. A. Wall, *J. Res. NBS* **70A6-422**, pp. 487-523 (Nov.-Dec. 1966).

> Key words: Degradation; nonisothermal kinetics; polymers; pyrolysis; thermal decomposition; thermogravimetry; thermolysis; stability of polymers.

Theoretical equations are developed for typical decompositions of polymers including those in which the volatilization does not follow a simple "reaction order" and those made up of a composite of several reactions of differing energies of activation. The effects of order, activation energy, heating rate and temperature dependence upon the calculated thermograms is illustrated. The literature on thermogravimetric kinetics is critically reviewed and coalesced into a logical and coherent development stressing the interrelation of methods and employing a consistent system of notation. As a result, a number of improved methods and new methods for the analysis of kinetic data applicable to the complex systems mentioned above are developed. It is concluded that methods involving a variable rate of heating or involving several thermogravimetric traces at different rates of heating are capable of establishing the uniqueness of kinetic parameters. A new method of determining initial parameters from rate-conversion data is developed. A novel concept is employed of programming reaction variables (in this case, the heating rate) in a manner which greatly simplifies the mathematics of the kinetic system and which shows promise of a wide range of applicability in the area of rate processes.

Viscoelastic behavior under large deformations, L. J. Zapas, *J. Res. NBS* 70A6-423, pp. 525-532 (Nov.-Dec. 1966).

> Key words: BKZ theory; constant rate of strain; creep; elastic fluid; nonlinear behavior; polyisobutylene; recovery; stress; relaxation.

The BKZ elastic fluid theory is used to correlate experimental results obtained in biaxial strain and steady simple shear. With a heuristic potential function involving three material properties, excellent agreement is obtained between theory and experiment. In the special case where one of the material properties is dominant, the behavior in steady simple shear is calculated from dynamic measurements in the infinitesimal range and is compared with actual data.

Statistical aspects of second and third law heats, W. S. Horton, *J. Res. NBS* 70A6-424, pp. 533-539, (Nov.-Dec. 1966).

> Key words: Bias of least squares estimators; coefficient of variation; correlated estimators; enthalpy adjustments; heat of vaporization; high temperature chemistry; overestimation of standard deviation; second law heat; slope estimators; third law heat; vapor pressure.

The effects of random errors and of nonconstant heat of vaporization upon the estimation of the second and third law heats of vaporization are examined. The most important conclusion is that the often noticed marked improvement in precision of the third law heat over that for the second law heat is real and is a natural consequence of the difference between the two estimators. The effects of systematic errors upon the two heats are not investigated here. Other results of interest, but of less importance because of the small magnitude of the effects, include: (1) the two heats are negatively correlated, (2) the second law heat is generally biased, (3) the third law heat is not the minimum variance unbiased estimator of the heat of vaporization, and (4) the standard deviation obtained from least squares fitting consistently overestimates the true standard deviation, but by a negligible amount. Any reversible process for which the equilibrium constant is treated by a similar procedure is governed by the same considerations. The results apply approximately at any temperature although the stimulus for these considerations comes from high temperature chemistry.

Density-temperature formulae for coexisting liquid and vapor and for freezing liquid parahydrogen, R. D. Goodwin. *J. Res. NBS* 70A6-425, pp. 541-544 (Nov.-Dec. 1966).

> Key words: Coexistence densities; freezing liquid densities; hydrogen; melting-line liquid densities; orthobaric densities; parahydrogen; vapor-liquid equilibrium.

A single formula is given for coexistence temperature as a continuous function of the vapor-liquid densities. With six coefficients and seven adjusted exponents, it may conveniently replace the several formulae formerly used in separate regions of the data. Freezing liquid densities are described by a simple power law in temperature, replacing more complicated formulae. Computed results are tabulated and compared with the derived data.

Solubility of $CaHPO_4 \cdot 2H_2O$ and formation of ion pairs in the system $Ca(OH)_2$-H_3PO_4-H_2O at 37.5 °C, E. C. Moreno, T. M. Gregory and W. E. Brown, *J. Res. NBS* 70A6-426, pp. 545-552 (Nov.-Dec. 1966).

> Key words: Solubility of calcium monohydrogen phosphate dihydrate at 37.5 °C; calcium-phosphate ion-pairs; solubility of dicalcium phosphate dihydrate; solubility of dibasic calcium phosphate dihydrate.

The solubility isotherm for $CaHPO_4 \cdot 2H_2O$ (DCPD) in the three-component system $Ca(OH)_2$-H_3PO_4-H_2O was determined in the *p*H range 3.5 to 6.8 by leaching a thermostated column of DCPD with dilute phosphoric acid solutions. In confirmatory experiments, equilibrium was approached both from super- and under-saturation by shaking DCPD with appropriate solutions. The calculated ionic activity product $(Ca^{++}) \times (HPO_4^{=})$, appeared to be a parabolic function of *p*H with a minimum near *p*H 5.0. The *p*H dependence of the ionic product could be accounted for by considering the ion pairs $[CaHPO_4]^\circ$ and $[CaH_2PO_4]^+$ as semi-empirical parameters. Under the condition of saturation with respect to DCPD, the activity of the pair $[CaHPO_4]^\circ$ must be a constant. The activity of the species $[CaH_2PO_4]^+$ was shown to vary directly with hydrogen ion activity. The activities of the two ion pairs were adjusted to give a set of *p*H-independent ionic activity products with a mean of $2.19 \pm 0.11 \times 10^{-7}$. The stability constants for $[CaHPO_4]^\circ$ and $[CaH_2PO_4]^+$ are $5.88 \pm 0.031 \times 10^2$ and 7.49 ± 0.039, respectively. Experiments were conducted to study the hydrolysis of DCPD to more basic calcium phosphates and the kinetics of these transformations is discussed. The significance of the ion pairs in human serum is considered.

Dissociation of some substituted phenols in 50-percent aqueous methanol as solvent, R. A. Robinson and R. G. Bates, *J. Res. NBS* 70A6-427, pp. 553-556 (Nov.-Dec. 1966).

> Key words: Dissociation constant; methanol-water mixtures; solvent effects; substituted phenols.

The dissociation constants of the following substituted phenols in 50 wt percent methanol have been measured at 25 °C: *o*-nitrophenol, *p*-nitrophenol, 4-methyl-2-nitrophenol, 2, 6-dichlorophenol, pentachlorophenol. The respective values found, expressed as *pK* values, are 7.91_7, 7.69_2, 8.28_4, 7.68_0, and 5.27_8. The dissociation constants of 4-methyl-2-nitrophenol and pentachlorophenol, again expressed as *pK* values, have been measured in water as solvent at 25 °C and found to be 7.59_7 and 4.82_0, respectively.

PAPERS FROM THE JOURNAL OF RESEARCH OF THE NATIONAL BUREAU OF STANDARDS, SECTION A. PHYSICS AND CHEMISTRY, VOLUME 71A, JANUARY-DECEMBER 1967

January-February 1967

Electric fields produced in cubic crystals by point defects, A. D. Franklin and D. J. Sparks, *J. Res. NBS* **71A1**-428, pp. 1-2 (Jan.-Feb. 1967).

> Key words: Electric fields; ionic crystals; lattice sums; point defects; polarization; NaCl; CsCl; CaF_2; ZnS.

Charged point defects in crystals polarize the surrounding ions. These induced dipoles contribute to the electric field in the crystal. In this paper, lattice sums for the calculation of this contribution are given for the NaCl, CsCl, CaF_2, and ZnS structures. Various positions for the defect are chosen, and the field evaluated near lattice sites in the vicinity of the defect, with radial (with respect to the defect) displacements of ±20 percent of the cation-anion distance allowed away from each lattice site. The lattice sums are expressed in power series, including terms up to cubic in the displacements, and the coefficients tabulated.

Heat capacity and thermodynamic properties of beryllium 1:3-aluminate, $BeO \cdot 3Al_2O_3$, from 15 to 390 °K, G. T. Furukawa and W. G. Saba, *J. Res. NBS* **71A1**-429, pp.3-8 (Jan.-Feb. 1967).

> Key words: Beryllium 1:3-aluminate; enthalpy; entropy; Gibbs energy; heat capacity; low temperature calorimetry; thermodynamic properties.

The heat capacity of beryllium 1:3-aluminate, $BeO \cdot 3Al_2O_3$, was determined from 15 to 380 °K and the thermodynamic properties calculated from 0 to 390 °K. The entropy at 298.15 °K was found to be 175.55 J deg^{-1} mol^{-1} (41.96 cal deg^{-1} mol^{-1}).

Dissociation constant of *m*-nitrophenol in 50 wt percent methanol-water solvent from 25 to 40 °C and related medium effects, B. J. Steel, R. A. Robinson, and R. G. Bates, *J. Res. NBS* **71A1**-430, pp. 9-12 (Jan.-Feb. 1967).

> Key words: Dissociation; electrolytes; methanol; *m*-nitrophenol; nonaqueous solvents; phenols; thermodynamics.

The dissociation constant of *m*-nitrophenol in 50 wt percent methanol-water as solvent has been determined at 25, 30, 35, and 40 °C. A spectrophotometric method was used, together with acidity functions for buffer solutions in 50 percent methanol derived from previous emf measurements. Values of the enthalpy and entropy changes on dissociation of the phenol have been calculated. A comparison with corresponding values for the dissociation of *m*-nitrophenol in aqueous solution affords a measure of the medium effects. The medium effect for *m*-nitrophenol lies intermediate between that for *o*-nitrophenol and that for *p*-nitrophenol.

On the calculation of moments of molecular weight distribution from sedimentation equilibrium data, I. H. Billick, M. Schultz, and G. H. Weiss, *J. Res. NBS* **71A1**-431, pp. 13-17 (Jan.-Feb. 1967).

> Key words: Molecular weight average; molecular weight distributions; moments; polydispersity; polynomial representation; sedimentation equilibrium.

In this paper we discuss a technique for calculating moments of polydisperse materials in terms of concentration readings along the cell. The proposed method minimizes dependence on data from the end points where they may be unreliable. An analysis is given of the errors involved in the use of the proposed method when the underlying molecular weight distribution is the Schulz distribution or the lognormal.

The far infrared spectrum of vulcanized natural rubber, J. E. Stewart and F. J. Linnig, *J. Res. NBS* **71A1**-432, pp. 19-23 (Jan.-Feb. 1967).

> Key words: Accelerators; far infrared; natural rubber; sulfur; tetramethylthiuram disulfide; vulcanization; zinc dibutyldithiocarbamate; zinc dimethyldithiocarbamate.

Earlier studies of the infrared spectra of rubber and some vulcanizates of rubber have been extended into the 650 to 33 cm^{-1} far infrared region. Some of the absorption bands originating in the crystalline portion of unvulcanized rubber have been studied by using polarized radiation and samples oriented by stretching. Vulcanization of rubber with sulfur alone produces a general weakening of all absorption bands and no new absorptions. Vulcanization with sulfur and an accelerator also results in a reduction in intensity of the rubber absorptions, but is accompanied by the appearance of new bands. When the accelerator is tetramethylthiuram disulfide (TMTD) the new bands are probably indicative of a thiocarbamate structure. When zinc dibutyldithiocarbamate is used as an accelerator a band probably due to zinc sulfide occurs. Vulcanization with TMTD alone produces only slight changes in the far infrared spectrum. However, when TMTD is used in the presence of zinc oxide a reaction occurs in which zinc dimethyldithiocarbamate (ZnDMDC) is formed. After vulcanization for a short period of time strong TMTD bands remain, but after long vulcanization the TMTD bands are replaced by ZnDMDC bands.

Irradiation of dextran and its aqueous solutions with cobalt-60 gamma rays, J. H. Flynn, L. A. Wall, and W. L. Morrow, *J. Res. NBS* 71A1-433, pp. 25-31 (Jan.-Feb. 1967).

> Key words: Aqueous solution; cross-linking; dextran; dextran triacetate; gamma irradiation; polymer degradation; postirradiative decay.

Cross-linking predominates over chain scission during the irradiation of concentrated aqueous dextran solutions by cobalt-60 gamma rays in the absence of oxygen. An extensive and long-lived postirradiative viscosity decay, which has not been previously reported, is attributed to the agency of hydrogen peroxide formed during the radiolysis of water. Solid dextran primarily degrades upon γ-irradiation while dextran triacetate is borderline between dominant scission and cross-linking. Both exhibit a postirradiative viscosity decrease when irradiated in the presence of water vapor. Electron spin resonance spectra of dextran in the solid state and in aqueous solution are presented and compared. Spin resonance spectral and chemical evidence concerning the mechanism of cross-linking and postirradiative decay reactions is presented. There is conflicting evidence for the presence of oxyradicals. Speculations are made concerning possible mechanisms of oxyradical formation and their role in the production of ether and peroxy linkages.

Synthesis of poly-*p*-oxyperfluorobenzylene and related polymers. A novel synthesis of the monomer 2,3,5,6-tetrafluoro-4-trifluoromethylphenol, J. M. Antonucci and L. A. Wall, *J. Res. NBS* **71A**1-434, pp. 33-41 (Jan.-Feb. 1967).

Key words: 1-*t*-butoxy-2,3,5,6-tetrafluoro-4-trifluoromethylbenzene; perfluoro-*p*-quinonemethide; polymerization; poly-*p*-oxyperfluorobenzylene; pyrolysis; 2,3,5,6-tetrafluoro-4-trifluoromethylphenol.

The synthesis and polymerization of 2,3,5,6-tetrafluoro-4-trifluoromethylphenol (heptafluoro-*p*-cresol) is described. The polymer, poly-*p*-oxyperfluorobenzylene (polyperfluoro-*p*-benzylene oxide), is probably formed through the perfluoro-*p*-quinonemethide intermediate obtained by the intramolecular loss of either hydrogen fluoride or a metal fluoride. The polymer has a structure analogous to that reported for the polymer derived from *p*-trifluoromethylphenol under similar conditions.

In the course of the synthesis of the monomer, heptafluoro-*p*-cresol, a novel synthetic method was discovered. The synthesis consists in the prior preparation of 1-*t*-butoxy-2,3,5,6-tetrafluoro-4-trifluoromethylbenzene and its subsequent thermal decomposition into the isobutylene and the desired cresol. Similarly, *N*-*t*-butyl-2,3,5,6-tetrafluoro-4-trifluoromethylaniline undergoes a similar liquid phase pyrolysis into isobutylene and 2,3,5,6,-tetrafluoro-4-trifluoromethylaniline. However, during the course of this pyrolysis, practically all of the aniline undergoes polymerization with concomitant loss of hydrogen fluoride. The polymer is formed by the same mechanism operative in the thermal polymerization of *p*-heptafluorocresol except that additional quantities of hydrogen fluoride can be eliminated from the -$NHCF_2$- segments of the polymer chain thereby introducing -N=CF- units into the polymer backbone.

Other *t*-butyl derivatives were synthesized and their thermal decomposition studied. Several possible mechanisms for the decomposition of these *t*-butyl compounds are considered.

Preparation, purity, and homogeneity of NBS standard samples 705 and 706, polystyrene, D. McIntyre, *J. Res. NBS* **71A**1-435, pp. 43-47 (Jan.-Feb. 1967).

Key words: Ash content; elemental analysis; homogeneity; lithium content; molecular weights; polymer; preparation; purity; sampling; standard sample; volatile content.

The state-of-art in the measurement of the molecular weights of macromolecules is discussed. The preparation of polystyrene standard samples 705 and 706 is described. The results and the description of the carbon-hydrogen microanalysis, the ash determination, the lithium analysis, and the volatiles determination are given. The sampling methods for determining the homogeneity of 705 and 706 are presented. Some evidence of heterogeneity appeared to be present, particularly for lot 705, but the experiment did not provide conclusive evidence of heterogeneity of the material.

Large-scale, preparative paper chromatography, H. L. Frush, *J. Res. NBS* **71A**1-436, pp. 49-52 (Jan.-Feb. 1967).

Key words: Chromatography on seed-test paper; large-scale paper chromatography; radioactive carbohydrates; use of heavy papers in preparative chromatography.

Simplified techniques are described for the use of heavy papers in large-scale, preparative chromatography. A new technique is illustrated for nondestructively locating bands of compounds on wet chromatograms. Capacities and behavior characteristics of Whatman seed-test paper and Whatman No. 17 paper are illustrated.

Infrared absorption spectra of some aldofuranoid, aldopyranoid, and acyclic 1-acylamido derivatives of sugars, R. S. Tipson, A. S. Cerezo, V. Deulofeu, and A. Cohen, *J. Res. NBS* **71A**1-437, pp. 53-79 (Jan.-Feb. 1967).

Key words: Absorption spectra; acyclic sugars; 1-acylamido sugars; aldofuranoid sugars; aldopyranoid sugars; infrared spectra.

The infrared absorption spectra of two glycofuranosylacetamides and their perbenzoates, and of eleven glycopyranosylacylamides and eight esters thereof, are presented and discussed. For comparison, the spectra of thirteen 1,1-bis(acylamido)-1-deoxyalditols and eight esters thereof are also given and discussed.

The useful correlations between structure and infrared absorption made by Barker and co-workers for certain carbohydrates, and by Nanasi and co-workers for some *N*-arylglycosylamines, cannot be extended to the 1-acylamido compounds we have studied. Certain of Verstraeten's correlations may have some diagnostic value.

March-April 1967

Relative enthalpy of beryllium 1:1-aluminate, $BeO \cdot Al_2O_3$, from 273 to 1173 °K. Thermodynamic properties from 273 to 2150 °K, D. A. Ditmars and T. B. Douglas, *J. Res. NBS* **71A2-438**, pp. 89-95 (Mar.-Apr. 1967).

Key words: Beryllium aluminate; chrysoberyl; drop calorimetry; enthalpy measurements; high-temperature calorimetry; mixed oxides; specific heat; thermodynamic properties.

The relative enthalpy of the beryllium aluminate $BeO \cdot Al_2O_3$ was measured by "drop" calorimetry from 273 to 1173 °K. The thermodynamic properties were calculated up to 2150 °K (approximately the melting point). For this calculation, the data were extrapolated above 1173 °K and the entropy at 273 °K, previously determined at the NBS, was used.

Relative enthalpy of beryllium 1:3-aluminate, $BeO \cdot 3Al_2O_3$, from 273 to 1173 °K. Thermodynamic properties from 273 to 2150 °K, D. A. Ditmars and T. B. Douglas, *J. Res. NBS* **71A2-439**, pp. 97-103 (Mar.-Apr. 1967).

Key words: Beryllium aluminate (1:3); drop calorimetry; enthalpy measurements; high-temperature calorimetry; mixed oxides; specific heat; thermodynamic properties.

The relative enthalpy of beryllium 1:3-aluminate, $BeO \cdot 3Al_2O_3$, was measured from 273 to 1173 °K. Thermodynamic properties were calculated up to 2150 °K (near the melting point) by extrapolating the present measurements and making them consistent with existing low-temperature data.

The heats of combustion of polytetrafluoroethylene (Teflon) and graphite in elemental fluorine, E. S. Domalski and G. T. Armstrong, *J. Res. NBS* **71A**2-440, pp. 105-118 (Mar.-Apr. 1967).

Key words: Aluminum fluoride; carbon tetrafluoride; fluorine; fluorine bomb calorimetry; graphite; heat of combustion; heat of formation; hydrogen fluoride aqueous; Teflon.

Bomb calorimetric measurements are reported for the combustion in fluorine of polytetrafluoroethylene (Teflon) and graphite-polytetrafluoroethylene mixtures. Mass spectrometric examination of the product gases showed CF_4 to be the only major product with $C_2F_6(g)$ present in only very small amounts. The completeness of combustion of the graphite was determined by chemical analysis of combustion residues and found to range from 97 to better than 99 percent. From the combustion data, the heats of formation $\Delta H^\circ_{f298}[CF_4(g)]$ and $\Delta H^\circ_{f298}[C_2F_4$ (solid polymer)] were determined to be -222.87 ± 0.38 kcal mol^{-1} and -197.82 ± 0.39 kcal (gfw $C_2F_4)^{-1}$, respectively. The uncertainties are estimates of the overall experimental errors.

A previously reported value for the heat of formation of AlF_3(c) is adjusted to be consistent with the present work. An evaluation of other data on CF_4 is presented. The heat of formation of CF_4(g) is combined with other work to derive the heats of formation of HF solutions at three specific concentrations.

Phase relations in the systems TiO_2-IrO_2 and SnO_2-IrO_2 in air, C. L. McDaniel and S. J. Schneider, *J. Res. NBS* **71A2**-441, pp. 119-123 (Mar.-Apr. 1967).

Key words: Dissociation; phase relations; SnO_2-IrO_2 system; solid solution; TiO_2-IrO_2 system.

The pseudobinary systems TiO_2-IrO_2 and SnO_2-IrO_2 were studied by x-ray diffraction after treatment at various temperatures in air. Their equilibrium phase diagrams were similar, with no intermediate phases detected in either system. Maximum solid solution of TiO_2 occurs with the addition of about 5 mole percent IrO_2 at 1040 °C. Solid solution of TiO_2 in IrO_2 extends to a maximum of about 12 mole percent TiO_2 at 1040 °C, the dissociation temperature. Limited solid solubility of SnO_2 in IrO_2 exists up to 3 mole percent SnO_2 at the dissociation temperature, 1025 °C. Solid solution in SnO_2 was not detected at temperatures up to 1400 °C.

Sample purity and the N.Q.R. of Cl^{35} in $KClO_3$ at 0 °C, D. B. Utton, *J. Res. NBS* **71A2**-442, pp. 125-126 (Mar.-Apr. 1967).

Key words: Measurements at 0 °C; nuclear quadrupole resonance thermometry; potassium chlorate.

It is shown that careful preparation is necessary to achieve a consistent value for the Cl^{35} nuclear quadrupole resonance frequency in $KClO_3$ samples at 273.16 °K (the triple point of water). This is illustrated by measurements on a number of samples. It is suggested that the N. Q. R. frequency of Cl^{35} in $KClO_3$ at 273.16 °K and atmospheric pressure is 28,213,372±2Hz. This value is compared with measurements made by previous workers which show a considerable spread.

Techniques for the growth of large single crystals of potassium of high purity, H. J. Foster and P. H. E. Meijer, *J. Res. NBS* **71A2**-443, pp. 127-132 (Mar.-Apr. 1967).

Key words: Crystal growth; fermi surface; orientation; potassium; spark cutting; zone refining.

The preparation of large, high purity, single crystals of potassium is described. First, high initial purity is obtained by careful zone refining. Then, a modification of the Bridgman technique is applied which leads to crystals with resistivity ratios up to 6800 at 4.2 °K. The modification consisted of a heat shield as described in the test. We concluded from the magnetoacoustic experiments that were subsequently done with these samples, that the samples had mean free paths of the order of 10^{-2} cm. Typical crystals were 7/8 in diam and about 8 in long, with growth direction along [110]. A description is given of an easy method of orientation as well as the use of a spark erosion technique to cut and polish the surfaces.

Synthesis of α-L-fucose-1-^{14} *C* (6-deoxy-L-galactose-1-^{14}*C*), H. S. Isbell, H. L. Frush, and N. B. Holt, *J. Res. NBS* **71A2**-444, pp. 133-136 (Mar.-Apr. 1967).

Key words: Carbon-14-labeled L-fucose; L-fuconic acid-*1*-^{14}*C*; L-fucose-*1*-^{14}*C*; radioactive carbohydrates; synthesis of radioactive sugars.

α-L-Fucose-*1*-^{14}*C* was synthesized in a radiochemical yield of 30 percent. The synthesis involved degradation of nonradioactive L-fuconic acid to 5-deoxy-L-lyxose and synthesis from this of α-L-fucose-*1*-^{14}*C* by use of ^{14}C-labeled cyanide in the cyanohydrin reaction. The resulting epimeric, ^{14}C-labeled aldonic acids were separated as either the barium or the sodium salts. Both salts of L-fuconic acid crystallize more readily than corresponding salts of the epimeric 6-deoxy-L-talonic acid.

The preparation of barium L-fuconate by the electrolytic oxidation of L-fucose in the presence of barium carbonate and barium bromide is described.

Deuterium isotope effects in α-β pyranose and in pyranose-furanose interconversions, H. S. Isbell and C. W. R. Wade, *J. Res. NBS* **71A2**-445, pp. 137-148 (Mar.-Apr. 1967).

Key words: Acid-base catalysis in D_2O; deuterium isotope effects; D-fructose; D-glucose; isotope effects; mechanism of mutarotation; mutarotation; pyranose-furanose interconversions; sugars in solution.

Rates of mutarotation, catalytic coefficients, and isotope effects are reported for the mutarotations of α-D-xylose, α-D-glucose, and β-D-fructose in H_2O and in D_2O at 20 °C. The isotope effects (k_h/k_d) for the mutarotation of β-D-fructose (a pyranose-furanose interconversion) parallel in striking manner the isotope effects for the mutarotation of α-D-glucose (an α-β pyranose anomerization). For each sugar, the isotope effect is lowest for the acid-catalyzed reaction and highest for the water-catalyzed reaction. The parallelism of the values obtained for the isotope effects under various conditions shows that the rate-determining steps in the two reactions are similar. Presumably, in both instances, the overall mutarotation arises from concurrent reactions operating on different species of the sugar and showing substantially different isotope effects. The gradual change in the isotope effect indicates that, under the conditions studied, three reactions take place concurrently.

The following isotope effects were found for the mutarotations at 20 °C: For α-D-glucose, $k_{H3O+}/k_{D3O+}=1.39$: $k_{H2O}/k_{D2O}=3.87$; and $k_B/k^*_B=1.83$. For β-D-fructose, $k_{H3O+}/k_{D2O+}=1.39$; $k_{H2O}/k_{D2O}=3.87$; and $k_B/k^*_B=1.92$. Mechanisms are presented for the several concurrent acid- and base-catalyzed mutarotation reactions.

Calculated transition strengths between the configurations $5d^86s$ and $5d^86p$ in Au III, H. Mendlowitz, *J. Res. NBS*, **71A2**-446, pp. 149-156 (Mar.-Apr. 1967).

Key words: Au III; calculated transition strengths; configurations $5d^86s$ and $5d^86p$.

The transition strengths have been calculated for transitions between configurations $5d^86s$ and $5d^86p$ of Au III based upon the wavefunctions given by Shadmi. These strengths have been compared with the estimated intensities given by Iglesias and are found to be in substantial agreement.

Hartree-Fock multiplet strengths for K I, Ca II, and Sc III, A. W. Weiss, *J. Res. NBS*, **71A2**-447, pp. 157-162 (Mar.-Apr. 1967).

Key words: Multiplet strength; self-consistent field; term values; wavefunctions.

Analytical approximations to Hartree-Fock wavefunctions have been computed for the 4*s*, 4*p*, and 3*d* states of K I, Ca II, and Sc III. Multiplet strengths for the 4*s*-4*p* and 4*p*-3*d* transitions in these ions are also computed. Examination of the results indicate that relaxation of the core in the field of the series electron accounts for a large portion of the core polarization effect, at least for the 3*d* level. Serious cancellation is found to invalidate the dipole velocity results of the 4*p*-3*d* transition in Ca II.

Oscillator strengths for the helium isoelectronic sequence, A. W. Weiss, *J. Res. NBS*, 71A2-448, pp. 163-168 (Mar.-Apr. 1967).

Key words: Atomic term value; oscillator strengths; wavefunctions.

Variational wavefunctions have been computed for the 1^1S, $2^{1,3}S$, $2^{1,3}P$, $3^{1,3}P$, and $3^{1,3}D$ terms of ions in the helium isoelectronic sequence from He through Ne^{+8}. The trial functions are Hylleraas type expansions, explicitly involving r_{12}, and with expansion lengths of around 50 terms, differing slightly for the different states. Oscillator strengths have been computed for all the allowed transitions by both the dipole length and velocity formulas. Agreement between these forms, comparisons with very accurate data for neutral helium, and the accuracy of the computed energies all point to considerable reliability of the results for the entire sequence, probably around 5 percent, if not better.

Solvent effects on the ultraviolet absorption of polystyrene, V. M. Story, D. McIntyre, and J. H. O'Mara, *J. Res. NBS*, 71A2-449, pp. 169-175 (Mar.-Apr. 1967).

Key words: Carbon tetrachloride; cyclohexane; ethylbenzene; extinction coefficient; polymer; polystyrene; solvent effects; ultraviolet absorption.

NBS Standard Sample Polystyrene 705 is shown to exhibit a small, but significant, hypochromism in the 38,300 cm^{-1} region in several solvents compared to the model compound, ethylbenzene. Beer's law is not obeyed for solutions of the polymer in all solvents. The concentration dependence of the extinction coefficient is related to the scattered light and its dependence on the activity coefficient of the solvent. The specific extinction coefficients for polystyrene 705 in cyclohexane and in carbon tetrachloride are 20.89 and 27.38, respectively.

May-June 1967

Measured relative enthalpy of anhydrous crystalline aluminum trifluoride, AlF_3, from 273 to 1173 °K and derived thermodynamic properties from 273 to 1600 °K, T. B. Douglas and D. A. Ditmars, *J. Res. NBS*, 71A3-450, pp. 185-193 (May-June 1967).

Key words: Aluminum trifluoride; drop calorimetry, enthalpy measurements; high-temperature calorimetry; phase transition; pretransition phenomena; specific heat; thermodynamic properties.

The enthalpy of a high-purity sample of anhydrous crystalline aluminum trifluoride, AlF_3, relative to that at 0 °C (273.15 °K), was precisely measured with an ice calorimeter and a "drop" method at 18 temperatures starting at 50 °C and proceeding in 50-deg steps to 900 °C (1173.15 °K). Thirty additional enthalpy measurements between 450 and 453 °C revealed a gradual transition. A simple general relation for the progress of transition when impurity is in solid solution is derived. The relation fits the observed transition data and indicates a first-order transition temperature of 455 °C (728 °K). X-ray powder patterns on the sample, measured in the Crystallography Section of the NBS, established the existence of a phase transition by showing not only the known hexagonal structure at room temperature (even after violent quenching from above the transition temperature region) but a new, simple-cubic structure at 570 °C (843 °K). The smooth heat-capacity curve formulated from the data merges very smoothly with that representing published precise low-temperature data. The common thermodynamic properties were derived, and are tabulated at and above 273.15 °K, with extrapolation up to 1600 °K.

The heat of formation of boron trifluoride by direct combination of the elements, E. S. Domalski and G. T. Armstrong, *J. Res. NBS*, 71A3-451, pp. 195-202 (May-June 1967).

Key words: Bomb calorimeter; boron; boron trifluoride; fluorine; heat of formation; Teflon.

The energy of combination of crystalline boron in gaseous fluorine was measured in a bomb calorimeter. The experimental data combined with reasonable estimates of all known errors may be expressed by the equation:

$$B(c) + 3/2F_2(g) = BF_3(g), \Delta H^\circ_{f298} = -271.03 \pm 0.51 \text{ kcal mol}^{-1}.$$

This result is compared with other recent work on and related to the heat of formation of boron trifluoride.

An equation of state for fluid parahydrogen from the triple-point to 100 °K at pressures to 350 atmospheres, R. D. Goodwin, *J. Res. NBS* 71A3-452, pp. 203-212 (May-June 1967).

Key words: Equation of state; hydrogen; parahydrogen; *PVT*-relations; thermodynamic properties.

This equation of state may be useful for interpolation and for computations which include thermodynamic properties of parahydrogen. A principal advantage is that it employs only one set of 24 coefficients for all fluid states. The basic form is relatively simple. And adjustment term for the critical region leads to good agreement with published PVT data and specific heats in this especially difficult area. The forms of fitting functions were developed by systematic trial methods using least squares to find the coefficients.

The dissociation constants of some disubstituted anilines and phenols in aqueous solution at 25 °C, R. A. Robinson, *J. Res. NBS*, 71A3-453, pp. 213-218 (May-June 1967).

Key words: Dissociation constant; substituted anilines; substituted phenols.

The dissociation constants of six disubstituted anilines and of five disubstituted phenols in aqueous solution at 25 °C have been measured using the spectrophotometric method. Consideration is given to the extent to which these dissociation constants can be predicted from corresponding values for monosubstituted anilines and phenols. In addition, the question as to whether the *pK* value of a substituted aniline can be predicted from the *pK* value of a phenol with substituents in the same positions is also investigated.

Third virial coefficient for air-water vapor mixtures, R. W. Hyland and E. A. Mason, *J. Res. NBS*, 71A3-454, pp. 219-224 (May-June 1967).

Key words: Chemical association; Lennard-Jones potential parameters; virial coefficients; water vapor-air mixtures.

The third interaction virial coefficient C_{aww} for air-water vapor mixtures is estimated in the temperature range 0 to 100 °C, by means of an approximate method based on molecular association. The results are believed accurate to within a factor of two. The value of C_{aww} can be combined with previous estimates of the other interaction coefficient C_{aaw} and the values of the third virial coefficients of pure air and pure water vapor, to give a quantitative description of the equation of state of air-water vapor mixtures through the complete third virial coefficient. It is shown that the maximum total contribution from both C_{aww} and C_{aaw} to the compressibility factor is only of the order of parts in 10^4 up to 100 °C and 100 atmospheres total pressure. At -50 °C, it can be shown by extrapolation of C_{aww} that the contribution of the C_{aww} term to the compressibility factor is only on the order of parts in 10^{11}.

Recrystallization and melting of partially melted stark rubber, D. E. Roberts, *J. Res. NBS* **71A3**-455, pp. 225-229 (May-June 1967).

Key words: Crystal size; crystallized rubber; heating rate; melting range; melting temperature; oriented; partial melting; recrystallization; rubber; slow melting; stark rubber.

Two specimens from a piece of stark rubber which had a melting temperature originally at 41 °C were partially melted at 38 °C and allowed to stand for 11 years, one at about 25 °C, the other at 38 °C. The first showed a continuous slow decrease in specific volume, while the second increased slowly in volume for 5 months and remained constant for about 5 months more before showing the continuous slow decrease. The melting temperature of the first increased to 45 °C and the melting range was broadened. The melting temperature of the second became 52 °C and the range was narrowed. Perfecting or enlarging of crystals and the effect of higher recrystallization temperatures have influenced the melting temperatures. The effect of heating rate is discussed in connection with slow increases in volume, attributed to relaxation of oriented regions, during melting.

Effects of a distribution of volume relaxation times in the annealing of BSC glass, P. B. Macedo and A. Napolitano, *J. Res. NBS*, **71A3**-456, pp. 231-238 (May-June 1967).

Key words: Annealing; borosilicate crown glass; glass; index of refraction; relaxation times; two-relaxation time model; volume relaxation.

The influence of a distribution of relaxation times is studied in annealing experiments. A two-relaxation time model is proposed, which permits the calculation of the distribution of relaxation times from the crossover data of Spinner and Napolitano as well as that of Ritland. This model also characterizes the structure of any glass in terms of two parameters. Thus, quenched equilibrium as well as nonequilibrium glass were compared with rate cooled glasses with respect to their behavior upon further annealing as well as their conductivity at low temperatures with excellent agreement.

Borosilicate crown glass was found to have a narrow distribution of relaxation times which is particular to associated liquid monomers rather than polymers. The results can be explained in terms of a topological model for the distribution of relaxation times. The temperature dependence of the viscosity is due to a true activation energy rather than a free volume effect.

July-August 1967

Kinetics of crystallization in multicomponent systems: I. Binary mixtures of *n*-paraffins, J. I. Lauritzen, Jr., E. Passaglia, and E. A. DiMarzio, *J. Res. NBS* **71A4**-457, pp. 245-259 (July-Aug. 1967).

Key words: Crystal growth; kinetics; multicomponent systems; *n*-paraffins; pair distributions; phase diagrams.

The kinetics of crystallization of a binary mixture of *n*-paraffins is treated using a theory for the rate of growth of chains in multicomponent systems. The kinetic chain is considered to be a strip of crystalline material composed of molecules of both components that is growing on a substrate of uniform thickness. This substrate is considered to be a close-packed surface step. Using the binary mixture of $C_{24}H_{50}$ and $C_{26}H_{54}$ as an example, the calculations are carried out by an iterative procedure so that the mean thickness of the strip equals that of the substrate. This procedure necessitates modification of the rate constants that would be used without this requirement. The rate of growth of the strips (total flux) is calculated as well as their composition over an appropriate range of temperature and a complete range of liquid compositions. The pair distribution in the strips is also determined. The substrate is assumed to be unkinked in the calculations, whereas the substrate is probably highly kinked in the actual system. For this reason the calculated total flux is probably not representative of the actual crystal growth rate in a binary mixture of $C_{24}H_{50}$ and $C_{26}H_{54}$. It is believed that the calculated compositions are reasonably accurate. For a binary mixture of longer *n*-paraffins (e.g., $C_{50}H_{102}$ $C_{52}H_{106}$) the substrate should have many fewer kinks, and the total flux calculated by this theory will be more closely related to actual crystal growth rate studies. However, no data exist for such systems.

Kinetics of crystallization in multicomponent systems: II. Chain-folded polymer crystals, J. I. Lauritzen, Jr. and E. Passaglia, *J. Res. NBS* **71A4**-458, pp. 261-275 (July-Aug. 1967).

Key words: Chain-folded crystals; crystal growth; kinetics; multicomponent systems; surface free-energy.

Using polyethylene as an example, the kinetics of growth of chain-folded polymer crystals is treated using a theory for the kinetics of growth of chains in multicomponent systems. The kinetic chain is considered to be a chain-folded strip growing on the lateral face of a chain-folded lamella, and the various components are the possible lengths l_j the polymer chain may form on folding at the end of the growing strip. Thus, the number of components is in principle infinite, but it is sufficient to take a number of the order of 20-50 for the calculations. By an iteration procedure, the calculations are carried out so that the average thickness of the strip is the same as that of the chain-folded lamella on which it grows. This necessitates modification of the rate constants that would be used without this requirement. The rate of growth, average thickness and its standard deviation, and the pair distribution are calculated as a function of undercooling and other relevant parameters of the system. The results for the rate of growth and thickness are similar to those of simpler theories, provided that the constant end-surface free-energy of those theories is replaced by a temperature dependent "effective" surface free-energy. The standard-deviation of the thickness is larger than commonly believed, values of 8 to 14 Å being typical. Consequently, the crystals as grown may have quite rough fold surfaces, although the equilibrium roughness will be less.

Infrared absorption spectra of 2-oxo-1,3-bis(phenylhydrazono) derivatives and related bis- and tris-phenylhydrazones, A. J. Fatiadi, *J. Res. NBS* **71A4**-459, pp. 277-285 (July-Aug. 1967).

Key words: Absorption spectra; infrared spectra; mono-, bis-, and tris-(phenylhydrazones); phenylazo compounds.

The infrared absorption spectra of six 2-oxo-1,3-bis(phenylhydrazones), four tris(phenylhydrazones), and six related mono- and bis-(phenylhydrazono) derivatives are presented. For comparison, partial spectra of ten selected aromatic azo compounds are also given and discussed.

The important features of the absorption bands arising from the N=N (1579 to 1558 cm^{-1} and 1447 to 1408 cm^{-1}), N—H (bending) (1557 to 1515 cm^{-1}), and Ph—N (1163 to 1123 cm^{-1}) groups are presented and discussed.

Dielectric constant of *n*-hexane as a function of temperature, pressure, and density, F. I. Mopsik, *J. Res. NBS* **71A4**-460, pp. 287-292 (July-Aug. 1967).

Key words: Clausius-Mossotti; density; dielectric constant; dilatometer; function; high pressure; *n*-hexane; pressure; three-terminal electrode set.

A description is given of apparatus employing a cell that is both a bellows dilatometer and a three-terminal electrode set for measuring simultaneously the density and dielectric properties of liquids as functions of temperature and pressure. Measurements are possible at temperatures from 120 °K to over 300 °K and pressures from 1 to 2000 atm with an uncertainty of 0.03 percent. The density, dielectric constant, and Clausius-Mossotti function of *n*-hexane have been measured for temperatures from 223 to 298 °K (-50 to 25 °C) and at pressures from 1 to 2000 atm. There is a linear decrease in the Clausius-Mossotti function with density and a decrease with temperature corresponding to an effective dipole moment of 0.085 debye.

Heat capacities and related thermal data for diethyl phthalate crystal, glass, and liquid to 360 °K, S. S. Chang, J. A. Horman, and A. B. Bestul, *J. Res. NBS* **71A4-461**, pp. 293-305 (July-Aug. 1967).

Key words: Annealed glass; crystal; diethyl phthalate; glass transformation; heat capacity calorimetry; molecular configurational state; normal and supercooled liquid; quenched glass; residual (configurational) entropy; thermodynamic properties.

Experimentally determined heat capacity values, precise to within 0.1 percent, and related thermal data are reported for quenched and annealed diethyl phthalate glasses from 10 °K to the glass transformation temperature, T_g (around 180 °K), for the liquid from T_g to 360 °K, and for the crystal from 10 °K to the melting temperature (269.9 °K). The mole fraction of liquid-soluble, solid-insoluble impurity in the sample as determined by fractional melting was 0.0012. Common thermodynamic properties calculable from the experimental data are reported. The heat capacities of the two glasses differ by more than the uncertainty of the measurements, and both lie below that of the crystal in the range from 30 to 75 °K. At low temperatures, just above 10 °K, the heat capacities of the glasses rise as much as 8 percent above that of the crystal.

Heats of formation of aluminum diboride and α-aluminum dodecaboride, E. S. Domalski and G. T. Armstrong, *J. Res. NBS* **71A4-462**, pp. 307-315 (July-Aug. 1967).

Key words: Aluminum diboride; α-aluminum dodecaboride; aluminum fluoride; bomb calorimeter; boron trifluoride; fluorine; heat of combustion; heat of formation; Teflon.

The energies of combustion of AlB_2 and α-AlB_{12} were measured in a bomb calorimeter using fluorine as the oxidant. Major problems of this investigation were the assessment of the state and distribution of impurities in the samples and the establishment of the stoichiometry of the aluminum boride phase. We obtain -16 ± 3 kcal mol^{-1} and -48 ± 10 kcal mol^{-1} for the heats of formation of AlB_2 and α-AlB_{12}, respectively. The uncertainties cited are the overall experimental errors. Their magnitudes are chiefly due to uncertainties in the impurity correction applied and the uncertainties in the heats of formation of the combustion products.

Effect of environment upon the melting point of Al_2O_3, S. J. Schneider and C. L. McDaniel, *J. Res. NBS* **71A4-463**, pp. 317-333 (July-Aug. 1967).

Key words: Al_2O_3; dissociation; environmental effects; melting point; premelting.

The melting point of Al_2O_3 has been determined in vacuum, air, argon, and helium utilizing iridium or tungsten containers. All melting point experiments were conducted in induction furnaces capable of heating small samples under blackbody conditions to 3000 °C in vacuum, 2600 °C in inert atmospheres, and 2400 °C in air. Temperatures were continuously monitored with a recording photoelectric pyrometer which has a sensitivity of ±0.2° at 1063 °C and ±1° at 2000 °C. Melting points were determined on specimens having a purity in excess of 99.9 percent. The data indicated that the melting point of Al_2O_3 determined in vacuum ($\sim 6.5 \times 10^{-5}$ torr) is 2051 °C (IPTS). The overall maximum uncertainty was estimated to be ±6 °C. The measurements themselves were precise within ±1.5 °C. Vacuum treatment had least detrimental effect upon the Al_2O_3 specimens. Each of the gaseous atmospheres including air yielded lower melting points for Al_2O_3, presumably due to a premelting phenomenon.

September-October 1967

Zeeman effect in positronium annihilation at low temperatures, W. C. Sauder and R. D. Deslattes, *J. Res. NBS* **71A5-464**, pp. 347-353 (Sept.-Oct. 1967).

Key words: Annihilation radiation; Compton wavelength of the electron; positronium; quenching.

The annihilation of positronium is discussed as a means of obtaining a precise measurement of the Compton wavelength of the electron. In particular the spectral line shape of the annihilation radiation is calculated for positronium thermalized in helium gas cooled to the region of its critical point with an applied magnetic field sufficient to yield a three photon to two photon branching ratio of unity for the $^3S_0$ component. Under such conditions the rapid thermalization of the positronium and the long half-life of two photon decay out of the predominantly triplet state make possible the production of rather narrow spectral distributions. An exact solution of the Zeeman effect in positronium is included. This study suggests that a wavelength determination beyond the one part per million level is attainable within the range of present technology.

Surface-layer relaxation in the dielectric spectrum of CaF_2 doped with GdF_3, A. D. Franklin, S. Marzullo, and J. B. Wachtman, Jr., *J. Res. NBS* **71A5-465**, pp. 355-362 (Sept.-Oct. 1967).

Key words: CaF_2; conductivity; crystals; defect pairs; dielectric relaxation; electrode capacitance; surface layers.

CaF_2 crystals doped with 0.1 percent GdF_3 were observed to develop surface layers when annealed above 700 °C in air, during application of Pt paste electrodes. The conductivity in these surface layers was much higher than in the bulk, due presumably to the large numbers of anion vacancies produced by dissolved oxygen. The presence of these high conductivity surface layers produced a relaxation in the dielectric spectrum with (1) an approximately temperature-independent magnitude, $\Delta\kappa$, (2) a relaxation time controlled by the conductivity of the surface layers, and influenced therefore by heat treatment of the specimen, and (3) an activation energy equal to that for conductivity of the surface layers, about 0.9 eV. This relaxation is sufficiently similar to dielectric relaxations observed previously in ionic crystals and ascribed to defect pairs to suggest that great care must be taken in interpreting dielectric measurements in these materials. What is thought to be dipole relaxation may in fact be due to the presence of thin layers accidentally present on the crystal. There is a marked electrode polarization effect in these crystals. The electrode capacitance at not-too-low frequencies depended upon the frequency and both the number and mobility of the charge carriers with 3/2 power laws.

Thermal expansion of rutile from 100 to 700 °K, R. K. Kirby, *J. Res. NBS* **71A5-466**, pp. 363-369 (Sept.-Oct. 1967).

Key words: Anisotropic crystal; Gruneisen's constant; interferometer; rutile; thermal expansion.

The thermal expansion of a single crystal of rutile (TiO_2) was determined in directions parallel to its crystallographic axes. A unique macroscopic technique was used wherein a cube-shaped specimen was cut from the anisotropic crystal, each of its six faces polished flat and nearly parallel to the face opposite it, and the expansion measured along each of its three body axes with an Abbe-Pulfrich interferometer. The relationship between the expansion along the body axes of the specimen and that in the crystallographic directions was determined from a Laue x-ray pattern. The unusual behavior of the thermal expansion that was observed can be explained by assuming an acoustical and optical contribution where the corresponding Gruneisen constants are 2.80 and 0.75 respectively.

Mass spectrometric study of photoionization. VII. Nitrogen dioxide and nitrous oxide, V. H. Dibeler, J. A. Walker, and S. K. Liston, *J. Res. NBS* **71A**5-467, pp. 371-378 (Sept.-Oct. 1967).

> Key words: Dissociation; fragment ions; ionization; mass spectrometer; molecule; NO_2; NO_2^+ N_2O^+; photoionization; threshold; ultraviolet; vacuum.

Photoionization efficiency curves are obtained for the molecule and fragment ions of NO_2 and N_2O from ionization threshold to 600 Å. Features of the molecule ion curves are ascribed to autoionization and the Rydberg levels are correlated with reported spectroscopic observations. The minimum onset of ionization for NO_2 occurs at 1272 Å (9.75 eV). The threshold value of 12.34 eV for the NO^+ fragment results in $D(NO-O)$ of 3.09 eV in good agreement with that calculated from thermochemical heats of formation. The 0^+ ion is apparently formed with 0.1 eV excess energy. The minimum threshold energy for the N_2O^+ ion is 962 Å (12.89 eV). The N_2^+ fragment ion curve has a threshold at 17.29 eV corresponding to the thermochemical bond energy, $D(N_2-0)=1.67$ eV. However a lower-energy threshold at 15.57 eV is ascribed to ionization of molecular nitrogen from an unknown source. There is no evidence for an ion-pair process. The ground state transition for NO^+ is forbidden by spin conservation rules. The observed threshold is 0.8 eV in excess of the calculated value and suggests a vibrationally excited state of the ion. The N^+ ion is also formed with excess energy.

Ionization constants of substituted benzoic acids in ethanol-water, G. M. Brauer, G. Durany, and H. Argentar, *J. Res. NBS* **71A**5-468, pp. 379-384 (Sept.-Oct. 1967).

> Key words: Allyl- and propenylbenzoic acids; change of *pK* with dielectric constant; Hammett sigma constants; ionization constants; *pK* values in ethanol-water; sigma constants in ethanol-water; substituted benzoic acids.

The thermodynamic ionization constants of meta and para substituted allyl- and propenylbenzoic acids were determined potentiometrically in aqueous ethanol of varying ethanol concentration. The *pK* values increase with increasing ethanol content. The relative acid strength does not vary with change in solvent concentration. The $\Delta pK/\Delta$ percent ETOH increases with ethanol content of the medium until a maximum is reached around 40 weight-percent ethanol. A plot of $pK+\log [H_2O]$ versus the reciprocal of the dielectric constant of the solvent gives a nearly linear relationship to about 44 weight-percent ethanol. From *pK* values found in the literature a similar linear relationship exists for other benzoic acids. With the exception of the *p*-propenylbenzoic acid the σ-substituent constants of the Hammett equation do not change greatly with ethanol concentration. This behavior may be indicative that the solvation shell surrounding the *p*-propenyl-acid differs from that of other benzoic acids.

Dissociation constants of some substituted nitrophenols in aqueous solution at 25 °C, R. A. Robinson, *J. Res. NBS* **71A**5-469, pp. 385-389 (Sept.-Oct. 1967).

> Key words: Dissociation constant; nitrophenols; substituted phenols.

The dissociation constants of twelve substituted phenols with a nitro group in the *o*- or *p*-position have been determined by spectrophotometric measurements in aqueous solution at 25 °C.

November-December 1967
(A Memorial Issue to William Frederick Meggers, July 13, 1888 to November 19, 1966)

The second spectrum of ytterbium (Yb II), W. F. Meggers, (Edited by C. E. Moore), *J. Res. NBS* **71A**6-470, pp. 396-545 (Nov.-Dec. 1967).

> Key words: Analysis of Yb II; atomic energy levels of Yb II; classified line of Yb II; spectrum, Yb II; ytterbium, second spectrum; Zeeman effect in Yb II.

The analysis of Yb II provides the most complete interpretation of a complex rare-earth spectrum known to date. The total number of energy levels is 315; 141 even levels and 174 odd levels. Three coupling schemes are represented: *LS*-coupling for the terms $4f^{14}ns\,^2S(n=6,7,8)$; $4f^{14}nd\,^2D(n=5,6,7)$ and $4f^{13}6s^2\,^2F^\circ$: J_IJ_{II}-coupling for the levels from the configurations $4f^{13}6s6p$ and $4f^{13}5d6p$; and J_IL_{II}-coupling for those from the $4f^{13}5d6s$ and $4f^{13}5d^2$ configurations.

More than 5000 Yb II lines are listed, of which about 80 percent have been classified, and 95 percent of the total intensity is accounted for. Observed Zeeman patterns for over 1000 lines have yielded *g*-values for 258 levels. The agreement between observation and theory is excellent as regards both the positions of the energy levels and the *g*-values. The theoretical work was done in collaboration with Racah and his associates over more than a decade.

A limit, 98150 K, giving an ionization potential of 12.17 eV, has been derived from the three-member ^2S series.

An improved description of technetium spectra (Tc I and Tc II), 2000 to 9000 Å, W. R. Bozman, W. F. Meggers, and C. H. Corliss, *J. Res. NBS* **71A**6-471, pp. 547-565 (Nov.-Dec. 1967).

> Key words: Spectra of technetium; technetium, spectra of; wavelengths of technetium.

A new description of technetium spectra has been made that is more complete and provides more accurate data on wavelengths than those reported heretofore. The observations were made in the region 2000 to 9000 Å with arc and spark sources. Larger samples of technetium and spectrographs of higher resolution were used and the number of lines reported (4500) is more than doubled. The intensities are estimated over a range from 1 to 20,000 and the relative strengths in arc and spark permit assignment of the origin of the lines to neutral atoms (3300 lines) or ions (1200 lines).

Lifetimes of energy levels in neutral iron, C. H. Corliss and J. L. Tech, *J. Res. NBS* **71A**6-472, pp. 567-573 (Nov.-Dec. 1967).

> Key words: Atomic spectra; energy levels; iron; iron, lifetimes in; lifetimes in Fe I; radiative lifetimes; spectroscopy.

Mean radiative lifetimes for 408 energy levels of neutral iron are calculated from the known transition probabilities of 3288 lines of Fe I.

Transition probabilities in argon I, C. H. Corliss and J. B. Shumaker, Jr., *J. Res. NBS* **71A**6-473, pp. 575-583 (Nov.-Dec. 1967).

> Key words: Argon; atomic spectra; transition probabilities.

In order to derive transition probabilities from intensity measurements of Ar I lines made by Dieke and Crosswhite, new transition probabilities for 26 lines from high levels in Ar I have been measured in a high current constricted arc. With these data, relative level populations of Ar I in Dieke and Crosswhite's microwave discharge are determined and transition probabilities for 240 lines of Ar I in the wavelength range 4100 to 9800 Å are derived. The new values are compared with other published values.

The fifth spectrum of praseodymium, V. Kaufman and J. Sugar, *J. Res. NBS* 71A6-474, pp. 583-585 (Nov.-Dec. 1967).

Key words: Atomic energy levels; isoelectronic sequence; praseodymium; rare earth; sliding spark discharge lamp; spectrum.

Twelve spectral lines of quadruply-ionized praseodymium in the region 840 to 2250 Å are reported. Five terms ($4f\,^2F$, $5d\,^2D$, $6s\,^2S$, $6p\,^2P$, and $7s\,^2S$) and the hyperfine splitting of the $6s\,^2S$ term are given. A calculation of the principal ionization energy ($Pr^{4+} \rightarrow Pr^{5+}$) leads to a value of 57.44 eV with an estimated uncertainty of ±0.05 eV.

Fundamental energy levels of neutral promethium (Pm I), J. Reader and S. P. Davis, *J. Res. NBS* 71A6-475, pp. 587-599 (Nov.-Dec. 1967).

Key words: Atomic spectroscopy; electronic energy levels; neutral atom; promethium; rare earth.

The spectrum of atomic promethium has been observed with a variety of light sources and spectrographs. The Zeeman effect has also been recorded. Analysis of the spectrum shows that the ground configuration of the neutral promethium atom is $4f^5 6s^2$. The relative positions (in cm^{-1}) of the low levels of this configuration are:

$^6H^\circ_{5/2}$	0.00	$^6H^\circ_{13/2}$	3919.03	$^6F^\circ_{5/2}$	5872.84
$^6H^\circ_{7/2}$	803.82	$^6H^\circ_{15/2}$	5089.79	$^6F^\circ_{7/2}$	6562.86
$^6H^\circ_{9/2}$	1748.78	$^6F^\circ_{1/2}$	5249.48	$^6F^\circ_{9/2}$	7497.99
$^6H^\circ_{11/2}$	2797.10	$^6F^\circ_{3/2}$	5460.50	$^6F^\circ_{11/2}$	8609.21

This group represents all levels of $4f^5 6s^2$ expected below 14.000 cm^{-1}. From these results the following values of interaction parameters and their estimated uncertainties have been inferred:

$$\zeta_{4f} = 925 \pm 20 \ cm^{-1} \qquad E^3 = 510 \pm 20 \ cm^{-1}$$

Data on 209 upper levels of even parity and 714 classified lines are given.

3.2. PAPERS FROM THE JOURNAL OF RESEARCH OF THE NATIONAL BUREAU OF STANDARDS, SECTION B. MATHEMATICS AND MATHEMATICAL PHYSICS, VOLUME 70B, JULY-DECEMBER 1966

July-September 1966

Error bounds for asymptotic solutions of differential equations. I. The distinct eigenvalue case, F. Stenger, *J. Res. NBS.* **70B3-180**, pp. 167-186 (July-Sept. 1966).

Key words: Asymptotic solutions; eigenvalues; error term; matrices; norm bounds; vector bounds; Volterra vector integral equations.

The method of Olver for bounding the error term in the asymptotic solutions of a second-order equation having an irregular singularity at infinity is extended to the general system of n first-order equations in the case when the eigenvalues of the lead coefficient matrix are distinct. Vector and norm bounds are given for the difference between an actual solution vector and a partial sum of a formal solution vector. Two cases are distinguished geometrically: In one it is possible to express the error vector by a single Volterra vector integral equation; in the other it is necessary to use a simultaneous pair of Volterra vector integral equations. Some new inequalities for integral equations are given in an appendix.

Error bounds for asymptotic solutions of differential equations. II. The general case, F. Stenger, *J. Res. NBS* **70B3-181**, pp. 187-210 (July-Sept. 1966).

Key words: Asymptotic solutions; error bounds; integral equations; matrices.

The results of the preceding paper are extended to the general system of n first-order differential equations having an irregular singularity of arbitrary rank at infinity. Formal solutions are explicitly constructed for the system in canonical form. Proofs of existence and uniqueness of solutions of integral equations defining the error are given. As an example, the case $n=2$ is solved completely, and a flow chart of the transformations of this case to canonical form is included.

On the approximation of functions of several variables, B. Mond and O. Shisha, *J. Res. NBS*, **70B3-182**, pp. 211-218 (July-Sept. 1966).

Key words: Approximations; convergence; multidimensional; polynomials; functions; variables; Hermite-Fejer; Bernstein; Chebyshev.

The purpose of this note is to point out how a certain type of approximation to functions of one real variable gives rise to similar approximations to functions of several variables. Information on the rapidity of convergence in the one dimensional case, yields at once corresponding information for the multidimensional case.

Finding a rank-maximizing matrix block, A. J. Goldman and M. Newman, *J. Res. NBS* **70B3-183**, pp. 219-220 (July-Sept. 1966).

Key words: Matrix; block; rank; algorithm.

An algorithm is developed for the following problem: Given three matrices of respective dimensions $s\times s$, $s\times t$, and $t\times s$, to find a $t\times t$ matrix such that the $(s+t)\times(s+t)$ matrix formed from the four blocks has maximum rank.

On certain discrete inequalities and their continuous analogs, A. M. Pfeffer, *J. Res. NBS*, **70B3-184**, pp. 221-231 (July-Sept. 1966).

Key words: Inequalities; norms; Wirtinger.

The purpose of this paper is to find inequalities between the L^2-norms of a function and its kth and mth derivatives.

October-December 1966

A random walk model of chain polymer adsorption at a surface. III. Mean square end-to-end distance, R. J. Rubin, *J. Res. NBS*, **70B4-185**, pp. 237-247 (Oct.-Dec. 1966).

Key words: Adsorption; chain polymer; critical energy; generating function; lattice model; partition function; random walk.

A 6-choice simple cubic lattice model of adsorption of an isolated polymer chain at a solution surface is investigated. The mean square components $\langle x^2(N)\rangle$ and $\langle z^2(N)\rangle$ of the end-to-end distance are computed as a function of the adsorption energy per monomer unit in the limit of a very long polymer chain. In the calculation, one end of the polymer chain consisting of N monomer units is constrained to lie in the surface; and $\langle x^2(N)\rangle$ and $\langle z^2(N)\rangle$ are, respectively, the mean square displacement of the free end of the chain parallel to the solution surface in one of the lattice directions and normal to the solution surface. The limiting value of $\langle x^2(N)\rangle/N$ as $N\rightarrow\infty$ is a continuous function of θ, the dimensionless adsorption energy per monomer unit, and is equal to 1/3 for $\theta\leqslant\ln(6/5)$ and $(1/2)[1+(1/4)(e\geqslant-1)^{-1}]^{-1/2}$ for $\theta^{\theta}\ln(6/5)$. The limiting value of $\langle z^2(N)\rangle/N$ as $N\rightarrow\infty$ is a discontinuous function of θ and is equal to 2/3 for $\theta<\ln(6/5)$, 1/3 for $\theta=\ln(6/5)$, and 0 for $\theta>\ln(6/5)$. The relation of these results to earlier investigations and the generalization of these results to other cubic lattice models is discussed.

Abscissas and weights for Gaussian Quadrature for $N=2$ to 100, and $N=125$, 150, 175, and 200, C. H. Love, *J. Res. NBS*, **70B4-186**, pp. 249-256 (Oct.-Dec. 1966).

Key words: Gaussian quadrature; integral equations; numerical integration; zeros of Legendre polynomials.

The abscissas and weights for Gaussian Quadrature of order $N=2$ to 100, and $N=125$, 150, 175, and 200 are given. The abscissas are given to twenty-four places and the error is estimated to be no more than one unit in the last place. The weights are given to twenty-three places and the error is estimated to be no more than 1 unit in the last place.

Transverse impact of a linear three-element spring and dashpot model filament: Theory, J. C. Smith, *J. Res. NBS*, **70B4-187**, pp. 257-264 (Oct.-Dec. 1966).

Key words: Characteristics; impact; linear viscoelasticity; partial differential equations; stress waves; wave propagation.

The mathematics of wave propagation in a viscoelastic filament subjected to constant velocity transverse impact is discussed. The equations governing the stress-strain-time behavior are assumed to be those for a linear model consisting of a spring coupled in parallel with a spring and dashpot in series. The nature of the solution is discussed, and a method is described for calculating the configuration, and the stress, strain, and particle velocity distributions along the impacted filament. The method used consists of an integration along the characteristics of the system of differential equations describing the problem.

Functions for thermal stress calculation near a transient heat source on a flat surface, S. Jarvis, Jr., and G. Hardy, *J. Res. NBS* **70B**4-188, pp. 265-272 (Oct.- Dec. 1966).

Key words: Elastic stress; heat transfer; plane strain; thermal stress; yield stress.

When an initially unstressed elastic solid at uniform temperature is subject to a transient, locally two-dimensional heat flux on a flat surface, the two-dimensional total stress field near the wall is locally determined for short times and may be constructed from the functions described in this report; Fortran programs are available for their computation. In particular, maximum total stress and total stress fields for initially large heat fluxes are readily obtained for estimations of yield probability.

PAPERS FROM THE JOURNAL OF RESEARCH OF THE NATIONAL BUREAU OF STANDARDS, SECTION B. MATHEMATICS AND MATHEMATICAL PHYSICS, VOLUME 71B, JANUARY-DECEMBER 1967

January-March 1967

Algorithms for frames and lineality spaces of cones, R. J.-B. Wets and C. Witzgall, *J. Res. NBS*, **71B**1-189, pp. 1-7 (Jan.- Mar. 1967).

Key words: Algorithm; cone; convex hull; face; frame; lineality space; linear programming.

A frame of a cone C is a minimal set of generators, and the lineality space L of C is the greatest linear subspace contained in C. Algorithms are described for determining a frame and the lineality space of a cone $C(S)$ spanned by a finite set S. These algorithms can be used for determining the vertices, edges, and other faces of low dimension of the convex hull of a finite set $H(S)$. All algorithms are based on the simplex method of linear programming. The problem of finding the lineality space can be successively reduced to problems in spaces of lower dimensions.

The coefficients of the powers of a polynomial, M. Newman, *J. Res. NBS*, **71B**1-190, pp. 9-10 (Jan.-Mar. 1967).

Key words: Binomial coefficients; bounds; polynomials.

It is shown that if $f(z)$ is a polynomial with no zeroes inside the unit circle and if r is any positive number, then the coefficients of $f^r(z)$ tend to zero like n^{-1-r}, and this is best possible.

Stable evaluation of polynomials, C. Mesztenyi and C. Witzgall, *J. Res. NBS*, **71B**1-191, pp. 11-17 (Jan.-Mar. 1967).

Key words: Evaluation; Newton form; polynomial; relative error; round-off.

A class of Newton forms

$$P(x)=a_0+a_1(x\text{-}x_0)+.\ .\ .+a_n(x\text{-}x_0)\ .\ .\ .\ (x\text{-}x_{n-1})$$

are discussed which admit a stable evaluation algorithm in an interval $[A,B]$. Stability is defined in the paper. The estimate

$$\frac{\Delta P}{|P|}\leqslant 2+6\frac{M'(L)L}{M(L)},$$

where $L:=B-A$ and $M(x):=|a_0+|a_1|x+.\ .\ .+|a_n|x^n$, is shown to hold for the relative error of evaluation of $P(x)$ in $[A,B]$.

On involutions, O. Shisha and C. B. Mehr, *J. Res. NBS*, **71B**1-192, pp. 19-20 (Jan.-Mar. 1967).

Key words: Inverses; involutions; real functions.

Two methods are described of constructing real functions over the reals which are one-to-one, assume every real value and are their own inverses, and several examples are given. It is also shown that such a function, if everywhere continuous, is either the function $f(x)\equiv x$ or else is strictly decreasing.

Minimum number of subsets to distinguish individual elements, P. R. Meyers, *J. Res. NBS*, **71B**1-193, pp. 21-22 (Jan.-Mar. 1967).

Key words: Classification design; combinatorics; set theory.

Given a set S of cardinality m, we determine the minimum cardinality $f(m)$ for a family F of subsets of S such that each $s\epsilon S$ can be expressed as the intersection of some subfamily of F. The problem is solved in the following inverse form. For a given number n of subsets of S, find $g(n)$: the maximum number of elements of S which can be written as the intersection of some of these subsets. We show that $g(n)$ is the largest binomial coefficient for combinations of n things.

***E*-Transforms,** F. M. Ragab, *J. Res. NBS*, **71B**1-194, pp. 23-37 (Jan.-Mar. 1967).

Key words: Fourier-transform; functional transforms; generalized MacRobert's function; Hankel transform, K-transform; Laplace transform, MacRobert's function; Y-transform.

The following transform pair is established:

$$g(x)=\int_0^{\infty}(xy)^k[Ep;\alpha_r:q;\rho_t:(xy)^{\pm n}]f(y)dy;$$

$$f(x)=n^2\int_0^{\infty}(xy)^{-k}E\left[\begin{array}{lcl}0 & \Big/ & q;\ 1-\rho_t\mp\frac{1}{n};\ (xy)^{\pm n}\\ 1;\mp\frac{1}{n} & \Big/ & p+1;\ 1-\alpha_r\mp\frac{1}{n},\ 1\end{array}\right]g(y)dy,$$

where n is any positive integer, and E is MacRobert's function and the generalized MacRobert's function, respectively.

Special choices of the parameters in the last transform lead in turn to the derivation of Hankel transform, Y-transform, K-transform, Fourier transform, Laplace transform and other integral transforms with tables to illustrate these new transforms.

Three observations on nonnegative matrices, A. J. Hoffman, *J. Res. NBS*, **71B**1-195, pp. 39-41 (Jan.- Mar. 1967).

Key words: Bounds; eigenvalues; nonnegative matrices.

Some results on nonnegative matrices are proved, of which the following is representative: Let $A=(a_{ij})$ be a nonnegative row stochastic matrix. If $\lambda\neq 1$ is an eigenvalue of A, then

$$|\lambda|\leqslant\min\left(1-\sum_j\min_i a_{ij},\ \sum_j\max_i a_{ij}-1\right).$$

Additional remarks on a theorem of M. Riesz, J. M. Smith, *J. Res. NBS*, **71B**1-196, pp. 43-46 (Jan.-Mar. 1967).

Key words: Commutator; matrix; orthogonal; quaternions; skew-symmetric; regular representation.

Let V be a real four-dimensional vector space, whose underlying geometry is the metric defined by the matrix

$$K=\begin{bmatrix}1 & 0 & 0 & 0\\ 0 & 1 & 0 & 0\\ 0 & 0 & -1 & 0\\ 0 & 0 & 0 & -1\end{bmatrix}$$

The following theorem is proved.

THEOREM: *If A and B are real, skew-symmetric, orthogonal (with respect to K) linear transformations on V, then $[A,B]=AB\text{-}BA$ is a multiple of a real, skew-symmetric, orthogonal (with respect to K), linear transformation on V.*

The theorem is proved by use of the first and second regular representations of the real quaternions.

Methods are given for constructing all 4 × 4 matrices which are skew-symmetric and orthogonal with respect to K. and all 4 × 4 matrices which are skew-symmetric (in the Euclidean sense) and orthogonal with respect to K.

April-September 1967

Poincare's conjecture is implied by a conjecture on free groups, R. D. Traub, *J. Res. NBS* **71B2&3-197**, pp. 53-56 (Apr.-Sept. 1967).

Key words: Free group; handlebody; homeomorphism; simply connected; topology; 3-manifold; 3-sphere.

Poincare's conjecture is implied by a single group-theoretic conjecture. The converse is also valid modulo a hypothesis on the uniqueness of decomposition of the 3-sphere as the union of two handlebodies intersecting in a torus.

Construction of *EPr* generalized inverses by inversion of nonsingular matrices, J. Z. Hearon, *J. Res. NBS* **71B2&3-198**, pp. 57-60 (Apr.-Sept. 1967).

Key words: *EPr* matrices; generalized inverse; matrix.

Any matrix B such that $ABA=A$ is called a C_1-inverse of A and a C_1-inverse of A such that $BAB=B$ is called a C_2-inverse of A. Some properties of such inverses are established. It is shown that if A is p-square of rank $q<p$ and P is any positive semidefinite matrix, whose rank is the nullity of A. such that $U=A+P$ is nonsingular, then $B=U^{-1}AU^{-1}$ is a C_2-inverse of A with the property that null space B=null space B^*. That such a P exists for arbitrary square A is shown. The relation between this result and the work of Goldman and Zelen is discussed.

A generalized matrix version of Rennie's inequality, J. Z. Hearon, *J. Res. NBS* **71B2&3-199**, pp. 61-64 (Apr.-Sept. 1967).

Key words: Generalized inverse; inequality; matrix.

The matrix version of Rennie's inequality and the finite-dimensional version of Kantorovich's inequality are obtained by considering a positive definite matrix and its inverse. Generalizations of these inequalities are obtained in which the inverse matrix is replaced by a generalized inverse with certain prescribed properties. From the generalization of the Kantorovich inequality follows a (finite-dimensional) generalization of an inequality due to Strang.

Polar factorization of a matrix, J. Z. Hearon, *J. Res. NBS* **71B2&3-200**, pp. 65-67 (Apr.-Sept. 1967).

Key words: Generalized inverse; matrix; partial isometry.

It is known that if A is a bounded linear operator with closed range on a Hilbert space then A can be factored as $A=UH$, with U a partial isometry and H nonnegative and self adjoint. For the finite-dimensional case a strictly matrix-theoretic derivation is given based on the concept of a generalized inverse. Certain properties of the factors are given as well as conditions under which H or both U and H are uniquely determined by A. A pivotal item in the derivation is the representation of a square partial isometry as the product of a unitary matrix and an orthogonal projection. This representation is new, of some interest in itself and greatly simplifies the derivations.

Two classical theorems on commuting matrices, M. Newman, *J. Res. NBS* **71B2&3-201**, pp. 69-71 (Apr.-Sept. 1967).

Key words: Commuting matrices; group representations; normal matrices; Schur's lemma; simultaneous triangularization and diagonalization.

Simple proofs are given of the following classical theorems: (1) An arbitrary set of commuting matrices may be simultaneously brought to triangular form by a unitary similarity. (2) An arbitrary set of commuting normal matrices may be simultaneously brought to diagonal form by a unitary similarity.

A converse to Banach's contraction theorem, P. R. Meyers, *J. Res. NBS* **71B2&3-202**, pp. 73-76 (Apr.-Sept. 1967).

Key words: Contractions; functional analysis: metric spaces; topology.

The class of all continuous self-mappings of a metrizable space which can become contractions (in the sense of Banach) under metrics compatible with the topology on the space is characterized. The characterization amounts to a converse to the Contraction Mapping Principle.

***E*-transforms (II),** F. M. Ragab, *J. Res. NBS* **71B2&3-203**, pp. 77-89 (Apr.-Sept. 1967).

Key words: *E*-functions; integral transforms; inversion formulas; kernels.

The following class of integral transform pairs is established

$$g(x)=\int_0^{\infty} E\left(\begin{matrix}\nu-ix, \nu+ix, \alpha_1, . . ., \alpha_p: \frac{1}{y}\\ \beta_1, . . ., \beta_q\end{matrix}\right) f(y)dy, \tag{1}$$

$$f(x)=\frac{x^{\nu-1}}{i\pi^2}\int_0^{\infty} yg(y)\left[\frac{1}{i}\sum_{i,-i} ix^{iy}\sin(iy+\nu)\pi E\right. \tag{2}$$

$$\left.\left(\begin{matrix}1-\nu-iy, \beta_1-\nu-iy, . . ., \beta_q-\nu-iy:x\\ 1-2iy, \alpha_1-\nu-iy, . . ., \alpha_p-\nu-iy\end{matrix}\right)\right] dy.$$

The kernel in the transform (1) is MacRobert's E-function and integration is performed with respect to the argument of this function. In the inversion formula (2), the kernel is likewise an E-function. but the integration is performed with respect to its parameters.

Known special cases of this general transform pair is the Kantorovich-Lebedev transforms pair:

$$g(x)=\frac{2}{\pi^2}x\sinh(\pi x)\int_0^{\infty} y^{-1}K_{ix}(y)f(y)dy,$$

$$f(x)=\int_0^{\infty} K_{iy}(x)g(y)dy,$$

and the generalized Mehler transform pair

$$g(x)=\frac{x}{\pi}\sinh(\pi x)\Gamma\left(\frac{1}{2}-k+ix\right)\Gamma\left(\frac{1}{2}-k-ix\right)\int_0^{\infty} P^k_{ix-1/2}(y)f(y)dy,$$

$$f(x)=\int_0^{\infty} P^k_{iy-1/2}(x)g(y)dy.$$

Criterion for the stability of numerical integration methods for the solution of systems of differential equations, A. I. A. Karim, *J. Res. NBS* **71B2&3-204**, pp. 91-103 (Apr.-Sept. 1967).

Key words: Numerical integration; propagation of error; stability; systems of differential equations.

The problem of studying the growth of the error is most important for the numerical solution of differential equations. In this paper the Wilf's criterion is generalized to be applied for systems of differential equations. A general theorem is investigated and regions of stability have to be determined. The use of an electronic computer is more essential for such regions to be characterized. These regions of stability have the property that, the error introduced at any stage tends to decay. The regions of stability for particular numerical methods are explicitly determined.

Discrete complex functions with prescribed boundary values and residues, E. L. Peterson, *J. Res. NBS* 71B2&3-205, pp. 105-110 (Apr.-Sept. 1967).

Key words: Analytic functions; complex analysis; Dirichlet problem; discrete analytic functions.

R. Isaacs, J. Ferrand, R. J. Duffin, and several others have developed a function theory for "discrete analytic functions" defined on "discrete regions" in the "discrete complex plane." In this paper we bring to light some combinatorial-topological properties of "simple discrete regions," and we study some basic properties of discrete analytic functions that are defined on simple discrete regions. These combinatorial-topological properties and basic properties are then used to establish an existence and uniqueness theorem for discrete complex functions with prescribed "boundary values" and "residues" on an arbitrary simple discrete region.

Numerical solution of second-order linear difference equations, F. W. J. Olver, *J. Res. NBS* 71B2&3-206, pp. 111-129 (Apr.-Sept. 1967).

Key words: Chebyshev series; difference equations; error analysis; Miller algorithm; recurrence methods; special functions.

A new algorithm is given for computing the solution of any second-order linear difference equation which is applicable when simple recurrence procedures cannot be used because of instability. Compared with the well-known Miller algorithm the new method has the advantages of (i) automatically determining the correct number of recurrence steps, (ii) applying to inhomogeneous difference equations, (iii) enabling more powerful error analyses to be constructed.

The method is illustrated by numerical computations, including error analyses, of Anger-Weber, Struve, and Bessel functions, and the solution of a differential equation in Chebyshev series.

Indefinite integrals involving Bessel functions, B. A. Peavy, *J. Res. NBS* 71B2&3-207, pp. 131-141 (Apr.-Sept. 1967).

Key words: Bessel functions; indefinite integrals.

Expressions are derived for the indefinite integrals,

$$\int rf(r)\, C_0(\alpha r)dr$$

$$\int rf(r)\, C_0^2(\alpha r)dr$$

$$\int rf(r) C_0(\alpha r)\, C_0(\beta r)dr \qquad \alpha \neq \beta$$

$$\int rf(r) C_0(\alpha r) Z_0(\lambda r) dr$$

where $C_0(\alpha r)$ are zero order Bessel functions, $Z_0(\lambda r)$ are zero order modified Bessel functions and $f(r)$ is a polynomial in r. In general, the expressions given for the integrals are given in terms of prescribed functions of the Bessel functions, and the coefficients of these functions are determined from a finite series, the terms of which are found from recurrence relationships that involve only the polynomial $f(r)$. Coefficients of the terms of the finite series are given in tabular form for up to an eleventh degree polynomial.

October-December 1967

Calibration designs based on solutions to the tournament problem, R. C. Bose and J. M. Cameron, *J. Res. NBS* 71B4-237, pp. 149-160 (Oct.-Dec. 1967).

Key words: Calibration; calibration designs; combinatorial analysis; difference sets; incomplete block designs; statistical experiment designs; tournaments; weighing designs.

In high precision calibrations one measures differences between nominally equal objects or group of objects and establishes a value for the individuals with reference to one or more standards. The solutions to the classical tournament problem, which calls for arranging v individuals into teams of p players so that a player is teamed the same number of times with each of the other players and also that each player is pitted equally often against each of the other players, provide balanced designs for scheduling the measurements. These designs are useful in weighing and other measurements when the objects to be measured can be combined into groups without loss of precision or accuracy in the comparisons.

This paper presents solutions to the tournament problem for all $v \leq 13$ and for $p \leq v/2$. The statistical analysis, a worked example, and computational procedures are given.

Bounds for the solutions of second-order linear difference equations, F. W. J. Olver, *J. Res. NBS* 71B4-238, pp. 161-166 (Oct.-Dec. 1967).

Key words: Chebyshev series; difference equations; error bounds; Miller algorithm; recurrence relations; special functions.

Simple bounds are established for the solutions of second-order homogeneous linear difference equations in ranges in which the solutions are exponential in character. The results are applied to a recent algorithm for the computation of subdominant solutions of second-order linear difference equations, homogeneous or otherwise. Strict and extremely realistic bounds are obtained for the truncation error associated with the algorithm in a number of examples, including Anger-Weber functions, Struve functions, and the solution of a differential equation in Chebyshev series.

Notes on automorphic functions: An entire automorphic form of positive dimension is zero, M. I. Knopp, *J. Res. NBS* 71B4-239, pp. 167-169 (Oct.-Dec. 1967).

Key words: Automorphic forms; discontinuous groups; Fourier expansion; *H*-groups.

Several new proofs are given of the fact that an entire automorphic form of positive dimension is zero. The first proof is modeled on the method used by Hecke to estimate the Fourier coefficients of cusp forms of negative dimension. The other proofs involve well-known theorems of complete function theory.

Solving equations exactly, M. Newman, *J. Res. NBS* 71B4-240, pp. 171-179 (Oct.-Dec. 1967).

Key words: Exact solutions; Hilbert matrices; linear equations; modular arithmetic.

A congruential method for finding the exact solution of a system of linear equations with integral coefficients is described, and complete details of the program are given. Typical numerical results obtained with an existing program are given as well.

A system of equations having no nontrivial solutions, H. Gupta, *J. Res. NBS* **71B**4-241, pp. 181-182 (Oct.-Dec. 1967).

Key words: Diophantine equations; Prouhet-Terry-Escott problem; symmetric functions.

The object of this note is to prove the THEOREM: *The system of equations*

$$a_1^r + a_2^r + \ldots + a_{n-1}^r = b_1^r + b_2^r + \ldots + b_{n-1}^r \quad r = 2, 3, \ldots, n;$$

has no nontrivial solutions in positive integers.

Remarks on cut-sets, J. W. Grossman, *J. Res. NBS* **71B**4-242, pp. 183-186 (Oct.-Dec. 1967).

Key words: Basic cut-sets; cut-sets; graph theory; network flows; mathematics; segs.

This paper gives a theorem on combinations of segs in a finite, connected, undirected graph. Then the theorem is specialized to combinations of cut sets, giving a theorem first proven by Mayeda. The paper contains an example showing that modifiers added to Mayeda's theorem by Yau, in the Journal of the Franklin Institute, January 1962, yield a false theorem. Finally, the paper discusses the practicability of algorithms developed by Mayeda and Yau and based on Mayeda's theorem.

A pseudo primal-dual integer programming algorithm, F. Glover, *J. Res. NBS* **71B**4-243, pp. 187-195 (Oct.-Dec. 1967).

Key words: Gomory algorithm; integer programming; linear inequalities; maximization.

The Pseudo Primal-Dual Algorithm dolves the pure integer programming problem in two stages, systematically violating and restoring dual feasibility while maintaining an all-integer matrix. The algorithm is related to Gomory All-Integer Algorithm and the Young Primal Integer Programming Algorithm, differing from the former in the dual feasible stage by the choice of cuts and pivot variable, and from the latter in the dual infeasible stage by the use of a more rigid (and faster) rule for restoring dual feasibility.

The net advance in the objective function value produced by the algorithm between two consecutive stages of dual infeasibility is shown to be at least as great as that produced by pivoting with the dual simplex method. Example problems are given that illustrate basic features and variations of the method.

Properties of a useful biorthogonal system, L. V. Spencer and P. Flusser, *J. Res. NBS* **71B**4-244, pp. 197-211 (Oct.-Dec. 1967).

Key words: Biorthogonal functions; gamma-ray penetration theory; neutron penetration theory; polynomial approximations.

In radiation penetration theory, infinite medium flux distributions have for some years been calculated using biorthogonal functions called $U_n^k(z)$. In this paper the spaces spanned by these functions, transformation kernels, generating functions, recursion relations, asymptotic trends for large n, many expansions, and relations with well-known orthogonal polynomials are worked out.

On even matroids, W. T. Tutte, *J. Res. NBS* **71B**4-245, pp. 213-214 (Oct.-Dec. 1967).

Key words: Binary; bridge-separable; even; graphic; matroid.

This article is intended as a supplement to an earlier paper entitled "Lectures on Matroids."

The author takes this opportunity to correct some errors in "Lectures on Matroids." Theorems 4.31 and 4.372 are valid only for binary matroids, the plane of 4.281 must be connected, and the word "reductions" is used in 3.48 instead of "contractions."

Matrices of class J_2, J. S. Maybee, *J. Res. NBS* **71B**4-246, pp. 215-224 (Oct.-Dec. 1967).

Key words: Chains; cycles; Jacobi matrices; triple diagonal matrices.

Let J_2 be the set of $n \times n$ complex matrices $A = (a_{ij})$ such that $a_{j_1j_2}a_{j_2j_3} \ldots a_{j_rj_1} = 0$ for all r such that $3 \leq r \leq n$ and all distinct $j_1, j_2, \ldots, j_r$. Then many properties of this set are given, which may be regarded as generalizations of the properties of the set of triple diagonal matrices.

Partially isometric matrices, J. Z. Hearon, *J. Res. NBS* **71B**4-247, pp. 225-228 (Oct.-Dec. 1967).

Key words: Generalized inverse; matrix; partial; isometry.

The complex, not necessarily square matrix A is called a partial isometry if the vectors x and Ax have the same Euclidean norm whenever x is in the orthogonal complement of the null space of A. The main results of the paper give necessary and sufficient conditions for a matrix to be a partial isometry, for a partial isometry to be normal and for the product of two partial isometries to be a partial isometry. A factorization for an arbitrary matrix involving partial isometries is given. The concept of a generalized inverse is used in establishing the primary results.

Symmetrizable generalized inverses of symmetrizable matrices, J. Z. Hearon, *J. Res. NBS* **71B**4-248, pp. 229-231 (Oct.-Dec. 1967).

Key words: Generalized inverse; symmetrizable matrix.

The matrix A is said to be symmetrizable by V when V is positive definite and AV is hermitian. Several lemmas regarding symmetrizability are given. For three classes of generalized inverses it is shown that if A is symmetrizable by V there exists a generalized inverse in each class which is symmetrizable by V. The Moore-Penrose inverse (or pseudo-inverse) of a matrix symmetrizable by V is also symmetrizable by V if and only if the matrix and the pseudo-inverse commute.

Optimum branchings, J. Edmonds, *J. Res. NBS* **71B**4-249, pp. 233-240 (Oct.-Dec. 1967).

Key words: Algorithms; arborescences; branchings; combinatorics; graphs; linear programming; traveling salesman; trees.

An arborescence T is a tree whose edges are directed so that each is directed toward a different node. Exactly one node of T, called the root, has no edge of T directed toward it. Let G be any directed graph with a real numerical weight on each edge. A good algorithm is described for finding in G (if there is one) a spanning arborescence, with prescribed root, whose edges have maximum (or minimum) total weight.

Systems of distinct representatives and linear algebra, J. Edmonds, *J. Res. NBS* **71B**4-250, pp. 241-245 (Oct.-Dec. 1967).

Key words: Algorithms; combinatorics; indeterminates; linear algebra; matroids; systems of distinct representatives; term rank.

Some purposes of this paper are: (1) To take seriously the term, "term rank." (2) To make an issue of not "rearranging rows and columns" by not "arranging" them in the first place. (3) To promote the numerical use of Cramer's rule. (4) To illustrate that the relevance of "number of steps" to "amount of work" depends on the amount of work in a step. (5) To call attention to the computational aspect of SDR's, an aspect where the subject differs from being an instance of familiar linear algebra. (6) To describe an SDR instance of a theory on extremal combinatorics that uses linear algebra in very different ways than does totally unimodular theory. (The preceding paper, Optimum Branchings, describes another instance of that theory.)

Bounds for the number of generators of a finite group, M. Newman. *J. Res. NBS* **71B**4-251, pp. 247-248 (Oct.-Dec. 1967).

Key words: Bounds; elementary abelian groups; generator rank; Sylow subgroups.

It is proved that if G is a finite group of order n, then the generator rank of G does not exceed the total number of primes dividing n and is equal to this number for infinitely many groups G.

3.3. PAPERS FROM THE JOURNAL OF RESEARCH OF THE NATIONAL BUREAU OF STANDARDS, SECTION C. ENGINEERING AND INSTRUMENTATION, VOLUME 70C, JULY-DECEMBER 1966

July-September 1966

Some harmonic properties of an oscillating Fabry-Perot interferometer, M. Gadsden and H. M. Williams, *J. Res. NBS*, 70C3-226, pp. 159-163 (July-Sept. 1966).

Key words: Fabry-Perot interferometer; airglow photometry.

The transmission of a spectral line through an air spaced Fabry-Perot interferometer is considered. The harmonic components of the transmission when the spacing of the interferometer is oscillated are discussed and it is found that the components can be used in a servocontrol system to offset drifts in the optical thickness of the interferometer. A possible use of such a controlled system in observations of the night airglow is discussed.

Precise reflection coefficient measurements with an untuned reflectometer, W. E. Little and D. A. Ellerbruch, *J. Res. NBS*, 70C3-227, pp. 165-168 (July-Sept. 1966).

Key words: Microwave; impedance; measurements; reflectometer.

The precision tuned reflectometer technique of reflection coefficient measurement is, at present, the most accurate technique available. Utilization of the technique requires the use of tuners and sliding terminations to eliminate or reduce the inherent errors of a directional coupler.

This paper describes a reflection coefficient measurement technique that approaches the accuracy of the tuned reflectometer. Instead of tuners, the technique uses an ideal one-quarter wavelength waveguide section to eliminate the measurement error introduced by finite directional coupler directivity and to reduce to second order the error introduced by an equivalent generator mismatch.

A comparison of the quarter-wave technique with the tuned reflectometer technique through the measurement of the reflection coefficient of three 9/16 inch coaxial waveguide terminations is also included.

A versatile ratio instrument for the high ratio comparison of voltage or resistance, A. E. Hess, *J. Res. NBS*, 70C3-228, pp. 169-172 (July-Sept. 1966).

Key words: DRRS (direct reading ratio set); junction; precision measurements; ratio; resistor; four-terminal; resistance decade; transresistance; URS (universal ratio set); VERI (versatile ratio instrument).

A 9-dial resistance ratio instrument capable of precise high ratio comparison of voltage or resistance (from 1/1 to $10^7/1$) is described. Also described is the modification of a 6-dial universal ratio set to permit its additional use as a versatile ratio instrument. Paramount to the accuracy of these high ratio instruments is the carefully adjusted "common point" junction which is briefly discussed.

Console for the rapid and precise comparison of volt boxes, P. H. Lowrie, Jr., *J. Res. NBS*, 70C3-229, pp. 173-185 (July-Sept. 1966).

Key words: Calibration; console; electrical; measurement; ratio; standards; voltage; volt box.

The comparison of volt boxes within uncertainties of ±0.01 percent or less has, in the past, been a long and difficult task at the NBS Boulder Laboratories. A console for this purpose recently put in use has reduced the time and labor to a great extent and, at the same time, has reduced the uncertainties associated with the measurement circuitry to less than 0.001 percent, thus allowing realizable calibration uncertainties of less than 0.005 percent. The console was designed as part of a system in which the operator was considered to be the decision-making link in the measurement chain. The circuitry, through the use of a contained computer and associated circuits, provides the operator with the data he requires in the form he chooses. The operator is thus freed from the need to consider minutiae, and thereby is able to concentrate on those factors requiring judgment.

Corrosion rates of binary alloys of nickel and iron measured by polarization methods, W. J. Schwerdtfeger, *J. Res. NBS*, 70C3-230, pp. 187-194 (July-Sept. 1966).

Key words: Corrosion rates; Ni-Fe alloys; polarization techniques; polarization rate; polarization resistance; polarization circuits; Ni-Fe pitting.

Specimens of ten binary alloys of nickel and iron containing 3, 5, 10, 16, 20, 30, 36, 50, 57, and 81 percent Ni and of the metals nickel and iron were immersed for 7 months in 265 gallons of city water to which had been added 3 percent by weight of sodium chloride.

Cathodic and anodic polarization curves of the specimens were obtained at about 22 periodic intervals throughout the exposure period. Corrosion currents, calculated from currents at breaks in the curves, were converted to corrosion rates expressed as weight losses by applying Faraday's law. The calculated weight losses were in reasonable agreement with the actual weight losses.

The polarization rates, $\Delta V/\Delta I$, of the specimens calculated from cathodic polarization curves (cathodic control prevailed) at several intervals throughout the exposure period were plotted on logarithmic coordinates with respect to the corrosion current densities calculated from breaks in the same curves. Similarly, the averages of these $\Delta V/\Delta I$ values were also plotted on logarithmic coordinates versus the actual corrosion rates expressed as weight losses. Both plots conformed to the theoretical slope of -1.

The effect of cold-drawing on the creep behavior of a nickel-4.2 percent aluminum alloy, W. D. Jenkins and W. A. Willard, *J. Res. NBS*, 70C3-231, pp. 195-205 (July-Sept. 1966).

Key words: Cold-drawing; creep; nickel alloys; Duranickel; nickel-aluminum precipitates; high temperatures; deformation.

Creep tests were made at 700, 900 and 1200 °F (644, 755 and 921 °K) on a nickel-4.2 percent aluminum alloy (Duranickel) initially as cold-drawn and as cold-drawn and age-hardened. Microstructural changes occurring during creep are correlated with the flow, fracture, and ductility of the specimens. Light and electron microscope observations indicate that increases in creep strength were associated with the formation of rather straight discontinuous slip bands, a well defined subgrain structure, small precipitates of Ni_3Al and a general distribution of these precipitates throughout the grains. Creep strength at 1200 °F was relatively unaffected by prior cold-drawing or aging. Intercrystalline cracking, accompanied by low ductility, was evident at 900 and 1200 °F and slow creep rates; whereas transcrystalline cracking and high ductility values were observed at 700 °F.

Magnetic transformation and the influence of plastic strain on the shear modulus of Fe-Cr-Ni alloys, R. P. Mikesell and R. P. Reed, *J. Res. NBS*, **70C3-232**, pp. 207-210 (July-Sept. 1966).

Key words: Antiferromagnetic; cold-work; Fe-Ni-Cr alloys; Neel temperature; shear modulus; stainless steel.

The Fe-18Cr-9Ni and Fe-19Cr-9Ni alloys exhibit a decrease in shear modulus between 76 and 20 °K. Susceptibility measurements confirm that a paramagnetic to antiferromagnetic transition occurs at about 40 °K in these alloys. The shear modulus for the Fe-25Cr-21Ni alloy did not decrease between 76 and 20 °K which was consistent with the fact that the alloy remained paramagnetic to 4 °K. The effect of cold-work on the shear modulus above and below the Neel temperature is discussed.

October-December 1966

Some techniques for measuring small mutual inductances, D.N. Homan, *J. Res. NBS*, **70C4-233**, pp. 221-226 (Oct.-Dec. 1966).

Key words: Auxiliary generator; bridge; coaxial choke; mutual inductor; stray magnetic field; transformer.

A method of measuring small mutual inductances is presented. The smallest inductor measured was 0.1 μH. The circuit is a transformer-ratio-arm bridge with multiple balances and is described in detail. Uncertainties are of the order of one part in 10^7.

Several ideas for the design and construction of suitable mutual inductance standards are presented.

Deflection of centrally loaded thin circular elastic plates on equally spaced point supports, A. F. Kirstein, W. H. Pell, R. M. Woolley, and L. J. Davis, *J. Res. NBS*, **70C4-234**, pp. 227-244 (Oct.-Dec. 1966).

Key words: Bassali's theory; concentric loading; circular plates; deflection; elasticity; experimental; flexure; point supports; simplified approximate solutions; thin plates.

Bassali's general theory for the flexure of the thin circular elastic plate supported at an arbitrary number of points and subjected to transverse load over an eccentric circle is specialized to the case of a centrally loaded plate supported at points equally spaced on a circle concentric with the center. Simplified methods for approximating the results predicted by the more complicated theoretical expressions for deflection are presented along with the experimental results from 138 tests. Both the experimental results and the simplified equations are compared with the theory and agreement is found to be good.

Reproducibility of germanium resistance thermometers at 4.2 °K, M. H. Edlow and H. H. Plumb, *J. Res. NBS*, **70C4-235**, pp. 245-254 (Oct.-Dec. 1966).

Key words: Germanium resistors; germanium resistor reproducibility; low temperature thermometry; reproducibility of germanium resistors; thermal cycling at low temperature; thermometry.

NBS has needed a set of very reproducible germanium resistors that would be capable of maintaining temperature scales. This paper describes our procedure for selecting such a set.

A group of germanium resistors from three commercial sources have been thermally cycled between 4.2 °K and room temperature. The resistance-temperature calibrations at 4.2 °K were made with reference to a liquid helium bath so that reproducible temperatures could be determined from liquid helium vapor pressure measurements. Seven resistors out of 25 demonstrated reproducibilities (of the 4.2 °K calibration) of about 0.001 °K after undergoing the multiple cyclings. Guided by these results, we procured twelve, new, similar resistors which were cycled in a comparable procedure. After 85 cycles, in which 14 resistance-temperature calibrations were performed at 4.2 °K for each resistor, 10 of the 12 resistors demonstrated reproducibilities of approximately 0.001 °K.

The resulting set of secondary thermometers have undergone calibrations in the temperature ranges, 2 to 5 °K and 2 to 20 °K; reports of this work will be published in the near future.

Calibration of vibrating-sample magnetometers, W. E. Case and R. D. Harrington, *J. Res. NBS*, **70C4-236**, pp. 255-262 (Oct.-Dec. 1966).

Key words: Ferro- and ferrimagnetism; magnetization; magnetometer calibration; measurement of magnetization; saturation magnetization; vibrating-sample magnetometer.

An evaluation of two of the most widely accepted methods for calibrating vibrating-sample magnetometers is given. The comparison method uses a material of known magnetization such as pure nickel. In the slope method, the magnetometer is calibrated from the low field linear slope of the magnetization curve of a sample of high permeability.

The primary source of error in the comparison method arises from an uncertainty in the absolute magnetization of nickel and its dependence on environmental conditions. The study indicated that better accuracy can be expected from the slope method. The use of pure iron in this method was found preferable to high permeability ferrites.

Notes on the use of propagation of error formulas, H. H. Ku, *J. Res. NBS*, **70C4-237**, pp. 263-273 (Oct.-Dec. 1966).

Key words: Approximation; error; formula; imprecision; law of error; products; propagation of error; random; ratio; systematic; sum.

The "law of propagation of error" is a tool that physical scientists have conveniently and frequently used in their work for many years, yet an adequate reference is difficult to find. In this paper an expository review of this topic is presented, particularly in the light of current practices and interpretations. Examples on the accuracy of the approximations are given. The reporting of the uncertainties of final results is discussed.

The apparent thermal radiation properties of an isothermal V-groove with specularly reflecting walls, R. B. Zipin, *J. Res. NBS*, **70C4-238**, pp. 275-280 (Oct.-Dec. 1966).

Key words: Reflectance; specular walls; thermal radiation; V-grooves.

The reflection of a parallel beam of light incident in a V-groove is treated for the case when the walls are specularly reflecting. Methods of calculating apparent reflectances and absorptances are given. Experiments have been performed to test the theoretical calculations, and the agreement has been found to be satisfactory.

PAPERS FROM THE JOURNAL OF RESEARCH OF THE NATIONAL BUREAU OF STANDARDS, SECTION C. ENGINEERING AND INSTRUMENTATION, VOLUME 71C, JANUARY-DECEMBER 1967

January-March 1967

Symmetrical bending of thin circular elastic plates on equally spaced point supports, A. F. Kirstein and R. M. Woolley, *J. Res. NBS*, **71C**1-438, pp. 1-10 (Jan.-Mar. 1967).

> Key words: Circular plates; concentric loading; design; elasticity; experiment; maximum stresses; symmetrical bending; symmetrically distributed load; theory.

A special application of Bassali's solution for transverse flexure of thin elastic plates supported at several points is presented for the case of symmetrical bending. Equations for moments, shearing forces, and stresses are developed which may be useful for design purposes. The experimental results although limited in quantity are in good agreement with the theoretical predictions.

Ultrasonic measurement of cylinder expansion at pressures to 40 kilobars, P. L. M. Heydemann and J. C. Houck, *J. Res. NBS*, **71C**1-439, pp. 11-17 (Jan.-Mar. 1967).

> Key words: Compressibility; cylinder distortion; high pressure; nickel; tellurium; ultrasonics.

For the accurate determination of internal pressures in solid-filled piston and cylinder devices the effective area and its change with pressure are very significant factors. The computation of the change of area with pressure from elastic theory leads however to considerable uncertainties.

The present paper describes how ultrasonic measurements made in solid-filled piston and cylinder devices to 45 kilobars are combined with measurements of the lengths of the samples as function of pressure and with ultrasonic measurements under hydrostatic pressure to yield values for cylinder expansion. The results are compared with values obtained from modified elastic theory.

A comparison of absorbed dose determinations in graphite by cavity ionization measurements and by calorimetry, B. Petree and P. Lamperti, *J. Res. NBS*, **71C**1-440, pp. 19-27 (Jan.-Mar. 1967).

> Key words: Absorbed dose; calorimeter; cavity ionization chamber; cobalt-60 gamma rays; comparison; graphite; $W\cdot\bar{s}_m$.

The absorbed dose in graphite from a cobalt-60 gamma-ray source was measured with a spherical air-filled cavity ionization chamber and with two spherical calorimeters. The instruments were constructed from high-purity graphite. The current per unit mass of air and the absorbed power per unit mass of graphite were determined with uncertainties of 0.40 and 0.17 percent respectively. When the two results are combined the value of $W_{air}\cdot\bar{s}_m$ is found to be 33.72 electron volts in graphite per ion pair in air, with an uncertainty of ±0.14 electron volts.

Germanium resistance thermometry in the range 2.1 to 5.0 °K, M. H. Edlow and H. H. Plumb, *J. Res. NBS*, **71C**1-441, pp. 29-41 (Jan.-Mar 1967).

> Key words: Calibration of germanium resistors; germanium resistors; thermometry.

The resistances of three encapsulated, hermetically sealed, arsenic-doped germanium resistors from a commercial source have been measured at every 0.1 °K from 2.1 to 5.0 °K in highly stabilized liquid helium baths; values of temperature were derived from vapor pressure measurements associated with the liquid bath.

Ten similar germanium resistors of common origin have been calibrated from 2.1 to 5.0 °K in a calibration comparator apparatus that is similar to a calorimeter in design. Calibrations were performed against a resistor that had been previously referenced to temperature through a helium-4 vapor pressure calibration.

Next, three of the resistors that were calibrated in the comparator apparatus were recalibrated in a liquid helium bath (at 2.2, 3.0 and 4.2 °K) and results from the two methods agree within ±1 milli-degree. The resistance-temperature data from both methods have been fitted to the polynomial equation

$$\log_{10} R = \sum_{n=0}^{m} A_n \cdot (\log_{10} T)^n$$

and the results of a computer program, which evaluates the coefficients, are presented.

Least squares technique for the analysis of periodic temperatures of the earth's surface region, T. Kusuda, *J. Res. NBS*, **71C**1-442, pp. 43-50 (Jan.-Mar. 1967).

> Key words: Earth temperature; least squares technique; thermal diffusivity of earth.

A least squares technique has been applied to periodic earth temperature data for the purpose of determining basic characteristics of earth temperature cycles, such as thermal diffusivity, average temperature, amplitude, and phase angle of the temperature cycle. A new procedure was developed for obtaining a single thermal diffusivity which represents an average over time and depth at a particular temperature site. This thermal diffusivity was obtained as a nonlinear part of least squares constants which yielded a best-fit harmonic curve to a given set of observed earth temperatures. The thermal diffusivity thus calculated and the calculation method developed are preferred to those obtained by current practice, which yields two thermal diffusivities, one based on amplitude decay and another on phase angle shift.

A new near-zone electric-field-strength meter, F. M. Greene, *J. Res. NBS*, **71C**1-443, pp. 51-57 (Jan.-Mar. 1967).

> Key words: Device, electroexplosive ordnance; field, near-zone electromagnetic; hazards, electromagnetic radiation; line, nonmetallic electrical transmission; line, semiconducting plastic transmission; meter, electric field-strength; telemetry, novel form of.

The National Bureau of Standards has recently completed the development of prototype instrumentation for measuring the electric-field components of complex, high-level, near-zone electromagnetic fields. The instrumentation is intended for use in evaluating hazards of high-level electromagnetic radiation to electroexplosive ordnance devices at military installations. The measuring range is from 0.1 to 1000 V per meter, at frequencies from 150 kHz to 30 MHz, with a present uncertainty of less than ±2 dB.

The design of the NBS meters is based on the use of a novel form of telemetry, which apparently has not been fully exploited heretofore. This involves the use of a completely nonmetallic electrical transmission line over which the field information is transmitted from the measuring antenna to a remote readout unit. The line is essentially "transparent" to the field being measured, and reduces the perturbation of the field two orders of magnitude below that normally experienced when using a metallic line. The high r-f line loss involved necessitates miniaturizing the r-f portions of the receiving and calibrating instrumentation and placing them and their associated battery supplies *inside* the measuring antenna. The design and performance of the meters are discussed in some detail.

Inductance and characteristic impedance of a strip-transmission line, R. L. Brooke, C. A. Hoer, and C. H. Love, *J. Res. NBS*, 71C1-444, pp. 59-67 (Jan.-Mar. 1967).

Key words: Characteristic impedance; inductance; and strip-transmission lines.

A general method is developed for determining the inductance and characteristic impedance of uniform transmission lines. A non-uniform current distribution is allowed in the transverse plane. The system is represented by a matrix equation which can be programmed for computer solution. The correct inductance and impedance are obtained as the result of a simple limiting process. The method is applied to one particular geometry, a four-tape stripline system. Results are given for the inductance, resistance, and current distribution as functions of frequency and resistivity for a particular geometry. A method for extending the results to strip lines with proportional dimensions is developed. An accuracy of one part in 10^5 was found to be feasible for the determination of the inductance per unit length.

Tensor permeability measurements at L-band frequencies using a degenerate mode cavity, L. B. Schmidt, R. D. Harrington, and W. E. Case, *J. Res. NBS*, 71C1-445, pp. 69-75 (Jan.-Mar. 1967).

Key words: Degenerate mode cavity; L-band cavity; polycrystalline garnets; tensor permeability.

The exact solution for the field equations of a cylindrical TM_{110} mode cavity has previously allowed accurate measurements of tensor permeability to be obtained at X-band frequencies. It is demonstrated that this method is also applicable at frequencies down to 1 GHz. A brief description of the cavity and measurement system for obtaining data at these lower frequencies is given. Both intrinsic and external permeability results on three commercially available polycrystalline garnets are shown. The larger size rods required for measurements at these frequencies result in some sample size effects in the data. In addition, a previously unreported absorption in the external tensor permeability of the materials was observed.

April-June 1967

An apparatus for measuring thermal expansion at elevated temperatures, B. D. Rothrock and R. K. Kirby, *J. Res. NBS*, 71C2-247, pp. 85-91 (Apr.-June 1967).

Key words: Controlled-gradient vacuum furnace; elevated temperatures; optical comparator; thermal expansion.

An apparatus has been developed for making precise measurements of the absolute thermal expansion of refractory materials at temperatures up to 1600 °C. This apparatus consists of an optical comparator and a controlled gradient vacuum furnace. Special care was taken on the techniques of measuring length and temperature and on the calibration of the microscopes and thermometers. The expansion data obtained with this apparatus on specimens of platinum and sapphire have a standard deviation of less than 30 ppm and are estimated to be accurate to within 50 ppm.

Determination and smoothing of Fourier coefficients representing piecewise continuous functions, B. A. Peavy, *J. Res. NBS*, 71C2-248, pp. 93-100 (Apr.-June 1967).

Key words: Continuous function; Fourier series; piecewise; smoothing.

This paper presents a method of solving for Fourier coefficients where the dependent variable can be expressed as a piecewise continuous function, when various conditions of continuity and smoothing are assumed. An example is included to show the effect of smoothing in the region of a discontinuity for a system composed of two materials that exhibit a discontinuity at their interface and surrounded by a third material which does not have a discontinuity. An advantage to be gained from smoothing is an increase in the convergence of a finite Fourier series representation of a piecewise continuous function in the region of the discontinuities.

A 2:1 ratio inductive voltage divider with less than 0.1 ppm error to 1 MHz, C. A. Hoer and W. L. Smith, *J. Res. NBS*, 71C2-249, pp. 101-109 (Apr.-June 1967).

Key words: Attenuator; bridge; high frequency; inductive voltage divider; ratio transformer.

A simple ratio transformer having a 2:1 ratio of input voltage to output voltage can be made with a ratio error less than 0.1 ppm from 1 kHz to above 1 MHz. Applications and sources of error are discussed. Experimental results leading to an optimum transformer design are given. A bridge to measure the ratio error to 0.025 ppm from 1 kHz to 1 MHz is also described.

A dual-load flow calorimeter for rf power measurement to 4 GHz, M. L. Crawford and P. A. Hudson, *J. Res. NBS*, 71C2-250, pp. 111-117 (Apr.-June 1967).

Key words: Coaxial; flow calorimeter; radio frequency power.

A new dual-load flow coaxial calorimeter power meter has been constructed at the National Bureau of Standards, Boulder Laboratories. Designed for use as a reference standard, the frequency range of the calorimeter extends up to 4 GHz and beyond. The power range extends from 2W to 100W with an error limit of 0.38 percent.

Design details, error analysis, and results of intercomparison with other standards are given.

Polymeric materials for dielectric reference specimens, A. H. Scott and J. R. Kinard, Jr., *J. Res. NBS*, 71C2-251, pp. 119-125 (Apr.- June 1967).

Key words: Dielectric constant; dissipation factor; frequency; fluorinated ethylene-propylene; humidity; polycarbonate; polyethylene; poly(1,4-cyclohexylenedimethylene terephthalate); polystyrene; poly(tetrafluoroethylene): time; reference specimens.

The results from a study of the effects of aging and humidity change on certain polymer specimens indicate it is possible to establish stable dielectric reference specimens. Specimens of polyethylene, polystyrene, polycarbonate, poly(tetrafluoroethylene) (PTFE), fluorinated ethylene-propylene polymer (FEP), and poly(1,4-cyclohexylenedimethylene terephthalate) were used in the investigation. Slow changes in the dielectric properties were observed on some specimens over a period as long as three years. Very long timed humidity runs indicate PTFE, and FEP to only a slightly less degree, are best suited for dielectric reference specimen preparation.

The sensitivity of the Dicke radiometer, D. F. Wait, *J. Res. NBS*, **71C2**-252, pp. 127-152 (Apr.-June 1967).

Key words: Dicke; microwave; radiometer; sensitivity; switching.

The literature is reviewed concerning the sensitivity of the Dicke radiometer, excluding gain fluctuations. Discrepancies are pointed out and a new derivation of sensitivity using a Fourier transform method is used to resolve these discrepancies and to extend the results to radiometers with lossy switches.

Experimentally it is shown that radiometers using a half-wave square-law, linear-law, intermediate-law, or envelope detectors all have a sensitivity equal to the theoretical full-wave square-law detector (within the ±20 percent uncertainty of the experiment).

Sensitivity of a correlation radiometer, J. J. Faris, *J. Res. NBS*, **71C2**-253, pp. 153-170 (Apr.-June 1967).

Key words: Correlation radiometer; differential time delay; gain fluctuations; imperfect multiplier; noise comparison; nonidentical amplifiers; sine-wave comparison signal.

The correlation radiometer is analyzed to determine the sensitivity that can be obtained under various operating conditions.

The radiometer using a sine wave comparison signal is analyzed and compared with the usual radiometer that employs a random noise for the comparison signal. It is found that the radiometer employing the sine wave comparison signal is the more sensitive of the two circuits, particularly in the case that the effective temperature of the input noise signal is greater than the effective input temperature of the amplifiers.

It is shown that if nonidentical amplifiers are used in the correlation circuit, the properties of the radiometer are determined by the portion of the amplifier response functions in the frequency interval that the two response functions overlap. The effect of amplifier gain fluctuations are considered, and although the correlation scheme reduces the effect of gain fluctuations, it is shown that they still do contribute to the output fluctuations of the radiometer.

Calculations are included showing that the effect of a differential phase shift between the two channels is a reduction in radiometer sensitivity. The same conclusion is reached concerning the effect of a differential time delay.

Finally, it is shown that if the comparison signal and the input signal have the same statistical properties, the requirements on the multiplier are less stringent than if the two signals have different statistical properties.

July-September 1967

Procedure for high precision density determinations by hydrostatic weighing, H. A. Bowman and R. M. Schoonover with Appendix by M. W. Jones, *J. Res. NBS* **71C3**-254, pp. 179-198 (July-Aug. 1967).

Key words: Air density; balance; balance calibration; balance equilibrium; balance sensitivity; density; double substitution weighing; hydrostatic balance; hydrostatic weighing; silicon density; substitution balance; volumetric measurement; water density; water weighing.

There are several simplifications which can be made in the performance of the hydrostatic experiment which lead to more reproducible results. The operation of single-pan two-knife balances is discussed, and simple modifications suggested to adapt it to hydrostatic work. A data philosophy is presented which will be particularly applicable to a generation of now-developing force measuring instruments when used in hydrostatic work. A simplified formula for air density is presented and a formula for estimating day-to-day variability in the density of water. A simple balance calibration procedure is presented in an appendix, and simplified methods of fabricating suspension wires and degassing sample surfaces are described. The use of these techniques is illustrated by measurements on silicon crystals which indicate process reproducibility of a standard deviation to about one part per million.

Study of the storage stability of the barium fluoride film electric hygrometer element, F. E. Jones, *J. Res. NBS* **71C3**-255, pp. 199-207 (July-Sept. 1967).

Key words: Adsorption; barium fluoride; electric hygrometer; humidity; thin films; vacuum.

A study of the aging properties of the barium fluoride film electric hygrometer element and of possible causes of the drift of calibration with time in storage has been made. It was found that exposure of aged elements to glow discharge bombardment resulted in near recovery of the prestorage calibration, indicating that the calibration drift was not irreversible and providing insight into the mechanism of aging. Based on the likelihood that aging was due, at least in part, to contamination of the barium fluoride film, production procedures were formulated which resulted in elements with significantly reduced drift. If an adjustment is made similar to the "lock-in" procedure in the operational use of radiosonde humidity elements, then the poststorage resistance values can be adjusted to correspond closely to the prestorage calibration curves. Experimental evidence supports the hypothesis that contamination of the elements by diffusion pumping fluid in the production process was a source of the calibration drift. Applications of the element as a research tool in cloud physics, atmospheric turbulence and radio refractive index structure studies, evaporation and evaporation reduction studies, water vapor flux determinations, and tropospheric humidity distribution studies are mentioned.

Torsion creep of circular and noncircular tubes, L. Mordfin, *J. Res. NBS* **71C3**-256, pp. 209-225 (July-Sept. 1967).

Key words: Creep; primary creep; shear; shell; stress analysis; thin wall; torsion; tube.

A torsion creep theory for noncircular tubes was developed by applying a multiaxial creep theory to a derived generalization of Bredt's equations.

A review of the literature revealed no torsion creep data on noncircular tubes. Hence, to evaluate the theory, a test program was carried out on twelve specimens of aluminum alloy structural tubing, of four configurations, at 400 °F.

Observed discrepancies between the torsion creep theory and experiment are smaller than variations in the measured creep properties of the specimen material from one tube configuration to another and are not appreciably greater than discrepancies between elastic torsion theory and experiment. Most of the observed discrepancies are consistent with measured anisotropy in the tubes, while other discrepancies are ascribed to nonhomogeneity in creep properties and a hydrostatic stress effect in multiaxial creep.

For the calculation of torsion stresses in circular tubes the thin-wall approximation is adequate for thickness-to-radius ratios up to one-tenth. For straight-sided tubes equivalent accuracy is obtained for effective ratios up to only one-twentieth. These criteria apply to creep conditions as well as to elastic conditions.

Digitized low-frequency phasemeter assembled from logic modules, J. E. McKinney, *J. Res. NBS* 71C3-257, pp. 227-238 (July-Sept. 1967).

Key words: Digital; phasemeter; logic circuit; low frequency; measurements; phase.

A digital phasemeter is described which is capable of operating from arbitrarily low frequencies to 10 kHz, for which the lower limit depends essentially upon the time available to the operator to make the measurement. The phasemeter involves a logic circuit which can be assembled easily from commercially available logic modules without the necessity of a proficiency in electronics. The output of the logic circuit is read into a conventional digital preset frequency-ratio meter. The determination is absolute and utilizes a time base. Accordingly, no calibration against a phase standard is necessary. The agreement between this phasemeter and a quality phase shifter was found to be within ±0.01° at 400 Hz, which is the accuracy specified by the manufacturer of the phase shifter. Considerable ability to ignore signal imperfections is inherent in this device.

October-December 1967

Measurements of the thermal conductivity and electrical resistivity of platinum from 100 to 900 °C, D. R. Flynn and M. E. O'Hagan, *J. Res. NBS* 71C4-258, pp. 255-284 (Oct.-Dec. 1967).

Key words: Conductivity; electrical conductivity; electrical resistivity; heat conductivity; Lorenz function; platinum; reference material; resistivity; standard; thermal conductivity.

Measurements have been made of the thermal conductivity and the electrical resistivity of commercial grade platinum (99.98% pure) in the temperature range 100 to 900 °C. The measurements have been made with a view to providing accurate data on the thermal conductivity of platinum to serve as a basis for establishing platinum as a thermal conductivity standard reference material. Two methods of measuring the thermal conductivity have been employed, one an electrical method and the other a nonelectrical method. In the electrical method, a direct current passed through a necked-down portion of the specimen and the thermal conductivity was determined in terms of the temperature and electrical potential distributions in the necked-down region. The second method was of the absolute guarded longitudinal heat flow type. The experiment was designed to permit measurements by both methods in the same apparatus and on the same specimen thereby providing as direct a comparison as possible between the methods. The data given by the two methods agree within experimental error and show the thermal conductivity of platinum to be a smoothly increasing function of temperature in the measured range. Additional measurements on samples of differing purities are necessary before platinum could be adopted as a thermal conductivity reference material.

Thermal conductivity and electrical resistivity of Armco iron, T. W. Watson, D. R. Flynn, and H. E. Robinson, *J. Res. NBS* 71C4-259, pp. 285-291 (Oct.-Dec. 1967).

Key words: Armco iron; conductivity; electrical conductivity; electrical resistivity; heat conductivity; heat transfer; iron; Lorenz function; resistivity; thermal conductivity.

New data are presented for the thermal conductivity and electrical resistivity of two samples of Armco iron. On a sample of material used in a round robin comparison between several laboratories, thermal conductivity was measured from −160 to +640 °C and electrical resistivity was measured from −195 to +1380 °C. On a sample of cold-worked Armco iron from a different lot, data are reported from −150 to +200 °C.

Heat flow in a right circular cylinder with internal heat generation: Applications to the determination of thermal conductivity, D. R. Flynn, *J. Res. NBS* 71C4-260, pp. 293-298 (Oct.-Dec. 1967).

Key words: Heat conduction; heat generation; heat transfer; neutron absorption; radioactive decay; thermal conductivity.

Expressions are developed which permit calculation of the temperature-dependent thermal conductivity of a cylindrical specimen in which heat is generated internally, e.g., by radioactive decay. The information needed consists of the experimentally determined temperature distributions on the surfaces of the cylinder, the heat flow through a central circular area at one end of the cylinder, and the rate of internal heat generation (which in general may be position-dependent). Numerical coefficients are tabulated for the case of uniform internal heat generation. The application of this calculation procedure to published methods of thermal conductivity determination is shown and an example is given.

Radiation-induced acoustic cavitation: Apparatus and some results, M. Greenspan and C. E. Tschiegg, *J. Res. NBS* 71C4-261, pp. 299-312 (Oct.-Dec. 1967).

Key words: Acoustic cavitation; alpha-particle-induced cavitation; cavitation; cavitation nucleus; cavitation threshold; fission-induced cavitation; neutron-induced cavitation; radiation-induced cavitation; threshold.

Equipment and techniques for acoustic cavitation work are described. The test liquid and its container form part of a self-sustaining programmable oscillator. Emphasis is laid on the treatment of the liquid necessary to yield reproducible results after artificial nucleation, especially by neutrons, α-recoils, and fission. With neutrons, for instance, the cavitation rate rises rapidly with acoustic (negative) pressure, and at fixed pressure is proportional to neutron flux. The cavitation events are random, and no appreciable induction or decay times are observed. Each cavitation arises from the action of a single neutron (or α-recoil, or fission). The cavitation "threshold" (roughly negative pressure below which cavitation is rare) is highly variable from liquid to liquid. Thresholds at about room temperature for liquids irradiated with 10 MeV neutrons ranged from 1 to 2 bars for *n*-pentane, ether, and freon 113 to over 50 bars for water.

Design of a new Kossel pattern generator, D. L. Vieth and H. Yakowitz, *J. Res. NBS* 71C4-262, pp. 313-318 (Oct.-Dec. 1967).

Key words: Divergent x-ray beam; instrument design; Kossel camera; Kossel method; x-ray instrumentation.

A Kossel pattern generator, designed and built at the National Bureau of Standards, is described in detail. The unit is modular and consists of an electron beam column, vacuum system, light microscope, film cassette, and Kossel camera. The camera component includes microgoniometric capabilities. The Kossel x-ray technique enables the investigator to obtain lattice spacing data precise to two or three parts per million, and orientation of crystals to 0.1° of arc. The Kossel pattern generator described permits data for such determinations to be obtained quickly and precisely.

The near-zone magnetic field of a small circular-loop antenna, F. M. Greene, *J. Res. NBS* 71C4-263, pp. 319-326 (Oct.-Dec. 1967).

Key words: Loop-antenna field strength; magnetic field-strength standard; mutual inductance of coaxial circular filaments; near-zone magnetic field; transmitting loop antenna.

An improved formula is derived for accurately computing the *near-zone* magnetic field of a small circular transmitting loop antenna. Such a field can serve as a reference standard for calibrating field-strength meters employing small receiving loop antennas in the frequency range 30 Hz to 30 MHz.

This formula includes correction terms for frequency (due to the finite time of propagation), as well as corrections for the finite radii of both the transmitting and receiving loops. Other formulas appearing in the literature often fail to include such corrections which can result in errors of up to 20 percent and more in computing standard-field values.

The NBS formula is derived by expanding the integrand of the retarded vector potential into an infinite series of spherical Hankel functions of increasing order. The resulting series expression is in error by less than 0.2 percent, is rapidly converging and simple to use without recourse to a table of functions or a computer.

3.4. MONOGRAPHS

Monographs are usually contributions to the technical literature which are too lengthy for publication in the Journal of Research. They often provide extensive compilations of information on subjects related to the Bureau's technical program. Until July 1959 most of this type of material was published in the Circular series. See "Price List of Available Publications", page 102.

Mono. 25, Section 5. **Standard x-ray diffraction powder patterns. Section 5.-Data for 80 substances,** H. E. Swanson, H. F. McMurdie, M. C. Morris, and E. H. Evans, NBS Mono. 25, Section 5 (Aug. 31, 1967).

Key words: Constants; crystal; lattice; measurements; powder-patterns; reference-intensities; standard; structure; x-ray diffraction.

Standard x-ray diffraction powder patterns are presented for 80 substances. Thirty-nine of these patterns represent experimental data and 41 are calculated. The experimental x-ray powder diffraction patterns are made with a Geiger counter x-ray diffractometer, using samples of high purity. All d-values were assigned Miller indices determined by comparison with theoretical interplanar spacings and from consideration of space group extinctions. The densities and lattice constants were calculated, and the refractive indices were measured whenever possible. The calculated x-ray powder diffraction patterns were obtained from published crystal structure data. The reported peak height intensities for calculated patterns were converted from integrated intensities.

Reference intensity values based upon the strongest line of corundum (113) in a 50 percent weight mixture are given for 73 materials.

Mono. 27, Supplement 2. **Bibliography of temperature measurement, July 1960 to December 1965,** L. O. Olsen and C. Halpern, NBS Mono. 27, Suppl. 2 (April 28, 1967).

Key words: Temperature; thermometry; thermocouples; thermistors; resistance thermometer; and radiation pyrometry.

There are presented in this supplement to NBS Monograph 27, "Bibliography of Temperature Measurement, January 1953 to June 1960" issued April 6, 1961, about 1700 additional references to the field of temperature measurement. (Supplement 2 also embraces the data presented in Supplement 1.) The period covered is from July 1960 to December 1965. With the exception of Part 1 which has been changed to include theory; calibration and temperature scales, the arrangement of material is the same as in Monograph 27. The journal abbreviations used are those employed in Chemical Abstracts. (Supersedes Supplement 1 to NBS Mono. 27.)

Mono. 32, Supplement. **Revision of the NBS tables of spectral-line intensities below 2450 Å,** C. H. Corliss, NBS Mono. 32, Suppl. (July 7, 1967).

Key words: Atomic spectra; intensities; spectral lines; ultraviolet.

A calibration is applied to the intensity measurements of the 1400 lines below 2450 Å in the NBS Tables of Spectral-Line Intensities. Tables of the new values are presented with the lines arranged by elements and by wavelengths.

Mono. 35, Supplement 1. **Bibliography and index on vacuum and low pressure measurement, January 1960 to December 1965,** W. G. Brombacher, NBS Mono. 35, Suppl. 1 (May 31, 1967).

Key words: Bibliography; low pressure measurement; techniques of vacuum measurement; vacuum index; vacuum measurement.

The bibliography, a supplement to NBS Monograph 35, of the same title, covers the years 1960 to 1965, inclusive, and includes 109 references for prior years not listed in Monograph 35. It contains 1787 references, 38 of which are to books. The references, besides those directly concerned with pressure measurement, include those on vacuum technology which may bear on the technique of vacuum measurement, such as on adsorption and desorption, diffusion of gases into solids, gas conductance and hardware such as pumps, seals and traps. Author and subject indices are provided.

Mono. 61. **The solar spectrum 2935 Å to 8770 Å. Second revision of Rowland's preliminary table of solar spectrum wavelengths,** C. E. Moore, M. G. J. Minnaert, and J. Houtgast, NBS Mono. 61 (Dec. 1966).

Key words: Elements in sun; equivalent widths of solar lines; identification of solar lines; molecules in sun; solar spectrum; wavelengths of solar lines.

The present compendium of solar spectrum wavelengths and intensities is essentially a second revision of Rowland's Table, corrected and supplemented by material from the Utrecht Photometric Atlas. Approximately 24,000 lines are listed. In a number of cases new wavelengths were determined. Measured equivalent widths from the Atlas records replace the Rowland estimated line intensities recorded in the 1928 revision. From these directly measured equivalent widths have been derived reduced widths, which, if necessary, were corrected for disturbing influences. The intensity behavior of atomic lines in the spot spectrum as compared with the spectrum of the solar disk is indicated by letters denoting strengthening, weakening, and the like. Atomic lines present only in the spot spectrum are, also, included, 223 in all.

Revised identifications of the lines, as to chemical origin, are given for both atomic and molecular lines. For classified atomic lines the lower excitation potential and multiplet number are listed. For molecular lines the rotation branch and quantum number, and the vibration band are indicated. Note numbers refer to notes in which the complete designation of the band is given.

An introductory text gives a detailed description of each column of the solar ledger. Figures are included to illustrate the procedure used to derive the observed equivalent widths $\Delta\lambda$(mÅ) and the reduced widths $\Delta\lambda/\lambda$(F).

Tables include counts of lines of each spectrum recorded in the identification column, leading lines in the first and second spectra, and summaries of molecules and elements present in the sun. About 73 percent of the lines are wholly or partially identified. Sixty-three elements are recorded as present. A number need further study. The number of molecules identified in the sun totals 11.

Mono. 75. **Colors of signal lights: Their selection, definition, measurement, production, and use,** F. C. Breckenridge, NBS Mono. 75 (Apr. 3, 1967).

Key words: Colors; lights; signal lights.

This Monograph is intended to serve as a reference work for all those concerned with the selection, specifications, and use of signal-light colors. It discusses the nature of the problem, and the mathematical representation, recognition, production, control, and use of such colors. The characteristics of different types of chromaticity boundaries and the purpose and effect of the requirement for similarity of chromaticity characteristics are given special consideration. The treatment is varied according to the intended use. The discussion of the control of colors and the section on the use of colors are nontechnical, whereas the section on the production of signal colors is designed for the colorimetrist who is faced with the problem of selecting limit filters or drafting a specification.

Mono. 88. **Heat treatment and properties of iron and steel,** T. G. Digges, S. J. Rosenberg, and G. W. Geil, NBS Mono. 88 (Nov. 1, 1966).

Key words: Annealing; case hardening; chemical composition; hardening; heat treatment; Ni-maraging steels; normalizing; stainless steels; structural steels; surface hardening; tempering; tool steels.

This Monograph is a revision of the previous NBS Monograph 18. Its purpose is to provide an understanding of the heat treatment of iron and steels, principally to those unacquainted with this subject. The basic principles involved in the heat treatment of these materials are presented in simplified form. General heat treatment procedures are given for annealing, normalizing, hardening, tempering, case hardening, surface hardening, and special treatments such as austempering, ausforming, martempering and cold treatment. Chemical compositions, heat treatments, and some properties and uses are presented for structural steels, tool steels, stainless and heat-resisting steels, precipitation-hardenable stainless steels and nickel-maraging steels. (Supersedes NBS Circ. 495 and NBS Mono. 18).

Mono. 97. **Microwave attenuation measurements and standards,** R. W. Beatty, NBS Mono. 97 (Apr. 3, 1967).

Key words: Microwave; attenuation; measurements; standards; tutorial.

A comprehensive and commentarial review of microwave attenuation measurement methods and standards is presented. In addition, a relatively new and more precise way of representing and analyzing an attenuation measurement is presented. This in turn permits more rigorous definitions and error analyses than were previously possible. Expressions for both mismatch and connector errors are presented.

The referral of microwave attenuation measurements to standards operating at lower frequencies is discussed with particular attention to the errors in the referral processes as well as the errors in the standards themselves. Standards operating at d-c, audio frequencies, and higher frequencies are included in this discussion which covers waveguide-below-cutoff attenuators and rotary vane attenuators.

Desirable characteristics are listed for attenuators which are suitable for calibration, and examples of these are given.

Measurement methods are classified and described, giving greatest emphasis to the intermediate-frequency substitution method using a waveguide-below-cutoff standard attenuator, and to d-c substitution techniques. Methods for measurement of small attenuations as well as methods not requiring reference to any standard attenuators are covered.

Comments are made on the accuracy and convenience of various methods, and references are given which cover most of the basic and important research in this field.

Mono. 98. **Abscissas and weights for Gaussian Quadrature for N=2 to 100, and N=125, 150, 175, and 200,** C. H. Love, NBS Mono. 98 (Dec. 28, 1966).

Key words: Integration; Gaussian; Quadrature.

The abscissas and weights for Gaussian Quadrature of order N=2 to 100 and N=125, 150, 175 and 200 are given. The abscissas are given to twenty-four places and the error is estimated to be no more than one unit in the last place. The weights are given to twenty-three places and the error is estimated to be no more than one unit in the last place.

Mono. 99. **Automatic typographic-quality typesetting techniques: A state-of-the-art review,** M. E. Stevens and J. L. Little, NBS Mono. 99 (Apr. 7, 1967).

Key words: Automated type composition; computerized typesetting; graphic arts; photocomposition; printing and publication.

This report describes the current state-of-the-art in automation of graphic arts composition, starting from either of two sources: (1) keyboard entry of manuscript material, or (2) mechanized input in the form of available perforated tapes or magnetic tapes. The gamut is covered from one extreme in which a skilled keyboard operator performs all of the compositor functions required to operate a typesetting machine, to the other extreme in which the input merely provides text whether or not including designation of desired font changes, followed by a high degree of automation through all operations leading to type set for printing.

Intermediate automation aids for the compositor functions, including characteristics of special-purpose digital computers and functions performed by typography programs for general-purpose digital computers, are reviewed.

Characteristics of automatically operated typesetting mechanisms, including hot metal casting machines and photocomposers, slow, medium and high speed, are outlined. Applications of new techniques for typographic-quality automated composition that are of interest in scientific and technical information centers, libraries and other documentation operations include sequential card camera listings, computer-generated KWIC indexes, photocomposition of technical journals, automatic composition of books containing both computer-produced tabular data and natural language texts, and the incorporation of mechanized processes throughout the publication cycle from the author's original manuscript preparation to the final printing. A bibliography of 363 references is included.

Mono. 100. **Trace characterization. Chemical and physical,** Editors, W. W. Meinke and B. F. Scribner, NBS Mono. 100 (April 28, 1967).

Key words: Electrochemical methods; electron and optical microscopy; nuclear methods; optical spectroscopy; symposium on trace characterization; trace characterization; x-ray spectroscopy.

A symposium on Trace Characterization, Chemical and Physical was held at the National Bureau of Standards October 3-7, 1966. This volume contains the texts of invited lectures, and summaries by the rapporteurs of the contributed papers and discussion sessions. Topics covered include trace characterization and the properties of materials; electrical measurements; electrochemical methods; optical and x-ray spectroscopy; x-ray diffraction; optical methods; chemical spectrophotometry; nuclear methods; mass spectroscopy; preconcentration; sampling and reagents; and electron and optical microscopy.

Mono. 101. **Low-temperature mechanical properties of copper and selected copper alloys. A compilation from the literature,** R. P. Reed and R. P. Mikesell, NBS Mono. 101 (Dec. 1, 1967).

Key words: Compilation; copper; copper alloys; low temperature; mechanical properties.

In the past 60 years considerable data has accumulated concerning the mechanical properties of copper and its alloys. It was felt that there was a great need to adequately document these results in one publication. Therefore a unique type of compilation is presented. The compilation is divided into four parts. The first section is intended for quick reference use for those who are interested in average values. The second section includes data from most of the investigators who have published results on the mechanical properties of copper and its alloys. The third section is composed of tables classifying the investigations which were not included in section two. These usually involve investigations in which data were obtained only at one temperature, such as room temperature. The fourth section lists, in alphabetical order, all references used.

Mono. 102. **Effects of finite lattice heat capacity on spin-lattice relaxation. Theory and numerical analysis,** R. L. Peterson, NBS Mono. 102 (Aug. 1, 1967).

Key words: Spin-lattice relaxation; phonon bottleneck; phonon-boundary scattering; spin-phonon interactions.

The transient magnetic behavior of a paramagnetic substance, after an initial disturbance, is considered theoretically for a variety of situations in which the lattice temperature rises as a result of energy flow from the magnetic (electron spin) system. The relaxation mechanisms considered are the direct process, involving interaction between spins and the resonant-phonon modes, and a T^9 Raman process, involving the remaining phonon modes. It is first assumed that the resonant and remaining modes are strongly coupled to each other, and that the helium bath has been removed (helium temperatures are assumed). The resulting transient behavior typically does not differ much from exponential relaxation (the rate increases somewhat during the relaxation), but the difference should be experimentally observable, particularly if the resonance line is inverted initially.

Next, the opposite extreme is considered--that in which the resonant and remaining modes are totally uncoupled; the helium bath is again assumed to have been removed. Two dramatic effects can then occur, depending upon initial conditions. One is the rapid decay to saturation from initial inversion, due to an avalanching creation of resonant phonons by the spins. The second is the pronounced inhibition of the subsequent decay, with the spins remaining near saturation. This decay rate is typically very much slower than the Raman rate, and is due to the flow of the resonant-phonon energy back into the spin system as the spin energy flows into the remaining lattice. Eventually the rate increases to the Raman rate characteristic of the final lattice temperature. Because of inelastic phonon scattering at crystal boundaries, which couples the phonon modes together, this effect of inhibited decay may be difficult to observe.

Finally, we consider the case of spins coupled only to the resonant phonons, which in turn are coupled to a constant temperature bath, whether this be the helium or the remaining modes. Recent phonon avalanche experiments are discussed in this context. It is pointed out that such experiments, performed in the absence of a bath, may provide a reliable measurement of inelastic phonon-boundary scattering.

Mono. 103. **Realistic uncertainties and the mass measurement process. An illustrated review,** P. E. Pontius and J. M. Cameron, NBS Mono. 103 (Aug. 15, 1967).

Key words: Accuracy; mass measurement; measurement; measurement process; precision; statistical control; uncertainty.

This paper gives a review of the concepts and operations involved in measuring the mass of an object. The importance of viewing measurement as a production process is emphasized and methods of evaluating process parameters are presented. The use of one of the laboratory's standards as an additional unknown in routine calibration provides an accuracy check and, as time goes on, the basis for precision and accuracy statements.

3.5. 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. See "Price List of Available Publications", page 104.

H102. **ASTM metric practice guide,** NBS Handb. 102 (March 10, 1967).

Key words: Metric system; international system (SI); conversion factors.

This Handbook, prepared by the ASTM Ad Hoc Committee on Metric Practice, is intended to assist persons confronted with the task of conversion between U. S. customary units and SI (metric) units.

Rules for conversion and rounding are explained in detail, and an extensive list of factors for conversion is included. A brief history of the development of SI is presented.

H103. **Tabulation of data on receiving tubes,** J. K. Moffitt, NBS Handb. 103 (Sept. 29, 1967).

Key words: Basing connections; characteristics; electron tubes; similar types; tabulation.

A tabulation of Receiving-Type Electron Tubes with some characteristics of each type has been prepared in the form of two major listings, a Numerical Listing in which the tubes are arranged by type number, and a Characteristic Listing in which the tubes are arranged by tube type and further ordered on the basis of one or two important parameters. The tabulation is accompanied by a listing of similar tube types and basing connections for the listed tubes. (Supersedes Handbook 83).

H104. **Tabulation of data on microwave tubes,** J. K. Moffitt, NBS Handb. 104 (Sept. 29, 1967).

Key words: Characteristics tabulation; electron tubes; microwave electron tubes; tabulation.

A tabulation of microwave electron tubes with characteristics of each type has been arranged in the form of two major listings, a Numerical Listing in which the tubes are arranged by type number, and a Characteristic Listing in which the tubes are arranged by the kind of tube, and further ordered on the basis of minimum frequency and power output. (Supersedes NBS Handbook 70).

3.6. 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, Annual Reports, Weights and Measures Conference Reports, and other subjects appropriate to the Miscellaneous series. See "Price List of Available Publications", page 103.

M236, 1967 Edition. **Services provided by NBS standard frequency stations WWV, WWVH, WWVB, and WWVL,** NBS Misc. Publ. 236, 1967 Edition (1967).

Key words: Broadcast of standard frequencies; high frequency; low frequency; standard frequencies; time signals; very low frequency.

Detailed descriptions are given of eight technical services provided by the National Bureau of Standards radio stations WWV, WWVH, WWVB, and WWVL. These services are: 1. Standard radio frequencies; 2. Standard audio frequencies; 3. Standard musical pitch; 4. Standard time intervals; 5. Times signals; 6. UT2 corrections; 7. Radio propagation forecasts; and 8. Geophysical alerts. In order to provide users with the best possible services, occasional changes in the broadcasting schedules are required. This publication shows the schedules in effect on June 1, 1967. Annual revisions will be made. Advance notices of changes occurring between revisions will be sent to regular users of these services upon request. Current data relating to standard frequencies and time signals are also available monthly in the Time and Frequency Services Bulletin. (Supersedes Misc. Publ. 236, 1966 Edition).

M260, 1967 Edition. **Standard reference materials: Catalog and price list of standard materials issued by the National Bureau of Standards,** NBS Misc. Publ. 260 (Sept. 15, 1967).

Key words: Analysis; catalog; certificate; characterization; composition; price list; property of material; purity of material; standard reference materials; standards.

This catalog describes the various Standard Reference Materials issued by the National Bureau of Standards. These materials are used to calibrate measurement systems and provide scientific information that can be referred to a common base. A schedule of prices and quantities is included for each material, as well as directions for ordering. Listed are the types and compositions of those chemical standards that are presently available. Announcements of new standard reference materials are made in the Federal Register, in scientific and trade journals, and in the Technical News Bulletin of the National Bureau of Standards. Changes affecting the current status of the various standards will be indicated by an insert sheet available quarterly from the Bureau. (Supersedes NBS Misc. Publ. 260-1965 Edition).

M260-11. **Standard reference materials: Viscosity of a standard lead-silica glass,** A. Napolitano and E. G. Hawkins, NBS Misc. Publ. 260-11 (Nov. 7, 1966).

Key words: Beam bending; fiber elongation; glass; glass standard; glass viscosity; lead-silica glass; restrained sphere; rotating cylinders; standard; standard reference material; viscosity; viscosity standard.

The viscosity of a lead-silica glass has been measured at the National Bureau of Standards and seven other laboratories. Determinations were made in the range of 10^2 to 10^{15} poises (1350-400 °C). Measurements were made by the rotating cylinder, restrained sphere, fiber-elongation, and beam-bending methods. The results have been critically evaluated and the glass has been issued as Standard Reference Material No. 711.

M260-12. **Standard reference materials: Homogeneity characterization of NBS spectrometric standards III: White cast iron and stainless steel powder compact,** H. Yakowitz, D. L. Vieth, R. E. Michaelis, NBS Misc. Publ. 260-12 (Sept. 19, 1966).

Key words: Microanalytical techniques; solids mass spectrometer; electron probe microanalyzer; NBS white cast iron sample (SRM 1175); stainless steel powder metallurgy compact; optical metallography; macroanalytical techniques; optical emission; x-ray spectrochemical analysis..

This paper describes a continuation of the NBS effort to characterize metal materials as to their suitability for use in calibrating microanalytical techniques such as the solids mass spectrometer and, especially, the electron probe microanalyzer An NBS white cast iron sample (SRM 1175) and a specially prepared stainless steel powder metallurgy compact have been investigated by means of electron probe microanalysis and optical metallography. Results for six elements in the cast iron and three in the stainless steel are given. It is concluded that neither of these materials is suitable for use for calibration in microanalytical techniques. It is emphasized, however, that this in no way affects the usefulness of the white cast iron material for macroanalytical techniques such as optical emission and x-ray spectrochemical analysis.

M260-13. **Standard reference materials: Mossbauer spectroscopy standard for the chemical shift of iron compounds,** J. J. Spijkerman, D. K. Snediker, F. C. Ruegg, and J. R. DeVoe, NBS Misc. Publ. 260-13 (July 28, 1967).

Key words: Mossbauer; spectroscopy; standard; differential chemical shift; quadrupole splitting; random error; systematic error; sodium nitroprusside; iron compounds; optical Mossbauer spectrometer; tandem Mossbauer spectrometer; velocity calibration.

The preparation, calibration, and use of the Standard Reference Material for chemical shift of iron compounds in Mossbauer Spectroscopy is described. This standard is a properly oriented single crystal of sodium pentacyanonitrosylferrate (II) dihydrate (sodium nitroprusside). Primary standards were calibrated with a high accuracy optical Mossbauer spectrometer and secondary calibrations were made with a tandem Mossbauer spectrometer. The midpoint between the two absorption peaks in the spectrum at 25.0 °C provide a useful velocity scale calibration of the spectrometer. Descriptions of the spectrometers used and the error analysis associated with the data are given. Suggested format for reporting Mossbauer spectra and their parameters is also presented.

M260-14. **Standard reference materials: Determination of oxygen in ferrous materials, SRM 1090, 1091 and 1092,** O. Menis and J. T. Sterling, NBS Misc. Publ. 260-14 (Sept. 23, 1966).

Key words: Vacuum fusion; inert gas fusion; oxygen; ferrous standard reference materials; CO by infrared absorbancy; homogeneity; certified value; eighteen cooperating laboratories.

A description is presented of methods used for the determination of homogeneity and the establishment of the oxygen values certified by NBS for three ferrous standard reference materials. These standards are represented by two low alloy materials, ingot and vacuum melted iron containing 484 and 28 ppm of oxygen respectively, and a high alloy steel containing 131 ppm of oxygen. The analyses of these materials are based on two vacuum fusion procedures. The poor results for the high alloy steel obtained by the first of these methods are explained. The first method is based on manometric measurements and depends on the conversion of CO to CO_2 by copper oxide and on a differential freezing of gases. In the second method a system is used which provides a highly efficient degassing of sample and a direct measurement of CO by infrared absorbancy. Additional data from an analysis by inert gas fusion method also indicate that the homogeneity of a single rod of ingot iron, over a wide range of sample size, has a relative standard deviation of less than two per cent. From control data and homogeneity studies it was ascertained that the uncertainty limits stated in the NBS certificate include the error due to the relative inhomogeneity between rods. Finally, data from eighteen laboratories cooperating in this program are presented.

M260-15. **Standard reference materials: Recommended method of use of standard light-sensitive paper for calibrating carbon arcs used in testing textiles for colorfastness to light,** E. Passaglia and P. J. Shouse, NBS Misc. Publ. 260-15 (July 21, 1967).

Key words: Light-sensitive paper; booklets of faded strips; fading characteristics; textiles; fading standardization.

The use of NBS Light-Sensitive Paper and NBS Booklets of Standard Faded Strips in the standardization of fading lamps is described. These lamps are used to determine the fading characteristics of textiles, and the light-sensitive paper is thus useful in standardizing this procedure.

M262-2. **Legibility of alphanumeric characters and other symbols: II. A reference handbook,** D. Y. Cornog and F. C. Rose, NBS Misc. Publ. 262-2 (Feb. 10, 1967).

Key words: Alphanumeric characters; displays; handbook; human factors; legibility; psychology; readability; standards; symbols; type faces; typography; visibility.

The major psychological findings and data in the field of the legibility of alphanumeric characters and other symbols are provided in this detailed Reference Handbook. Summaries and extracts of information for 203 experimental, developmental, review, and other legibility reports are presented and are multiply indexed in depth by (1) a matrix, cross-reference index (article versus functional variables - environmental typographical), (2) author indexes (alphabetical and chronological), and (3) a character-face-name index. These Handbook entries are further indexed by the permuted title index in NBS Miscellaneous Publication No. 262-1, "Legibility of Alphanumeric Characters and Other Symbols: I. A Permuted Title Index and Bibliography." Selected samples of several important experimental and other faces are presented in an appendix.

M273. **Critical phenomena. Proceedings of a conference, Washington, D.C., April 1965,** Editors, M. S. Green and J. V. Sengers, NBS Misc. Publ. 273 (Dec. 1, 1966).

Key words: Critical phenomena; critical point; second order phase transition; singularities; Pade approximate fluctuations; opalescence; X-transitions.

A conference on Critical Phenomena was held at the National Bureau of Standards, April 5-8, 1965. This volume contains 30 of the papers included in the program, together with the discussions which followed oral presentation. Topics covered include equilibrium critical phenomena in fluids, critical phenomena in ferro- and antiferromagnets, logarithmic singularities in specific heats, elastic, and inelastic scattering, and transport and relaxation phenomena in the critical region.

M277, Supplement 1. **Photonuclear data index,** NBS Misc. Publ. 277, Supplement 1 (Oct. 1967).

Key words: Bibliography; data index; elements; isotopes; nuclear physics; photonuclear reactions.

This index, a supplement to NBS Miscellaneous Publication 277, primarily covers data published in the period dated January 1, 1965 through the middle of April 1967. Organized by element and isotope, each entry in the index supplies quantitative information for a specific reaction on the ranges of excitation energy, source energy, detected particle energy, and emission angles for reaction produced covered in each reference. Information is also given on the type of measurement and detector used.

M280. **Hydraulic research in the United States, 1966,** Editors, H. K. Middleton and G. Kulin, NBS Misc. Publ. 280 (Sept. 8, 1966).

Key words: Hydraulic; hydrology; naval hydrodynamics.

Research and development projects being conducted in 1966 in hydraulic and hydrologic laboratories of universities and Federal agencies throughout the United States and Canada are briefly described. A list of the contributing laboratories is given. The status of continuing projects covered by previous issues of the publication is reported upon, as well as on new projects in progress, the results of completed work are given. References to publications relating to the projects and an extensive subject index are included.

M281. **Bibliography on flame spectroscopy. Analytical applications, 1800-1966,** R. Mavrodineanu, NBS Misc. Publ. 281 (Feb. 23, 1967).

Key words: Flame; spectroscopy; analytical emission; atomic absorption; electrical discharge; bibliography; indexed.

Flame spectroscopy, especially in its analytical applications, continues to be an active field of study. Its literature is growing steadily, and the use of flame photometry in many specialized applications calls for a comprehensive indexed bibliography. This collection consists of 5,113 references to works on flame spectroscopy, selected with emphasis toward analytical measurements. It covers the period from 1800 to 1966. Subject indexes, keyed by number to the references cited, precede most of the sections.

M282. **National Bureau of Standards Brochure, 1966,** NBS Misc. Publ. 282 (Nov. 1966).

Key words: Engineering measurements and standards; measurement standards; properties of matter and materials.

An attractive, easy to read account of the current activities of the National Bureau of Standards. The brochure discusses the primary activities of the Bureau -- basic measurement standards, properties of matter and materials, engineering measurements and standards -- and provides interesting background on NBS technical assistance and services, NBS staff and recent accomplishments.

M283. **Technical highlights of the National Bureau of Standards, Annual Report Fiscal Year 1966,** NBS Misc. Publ. 283 (Apr. 1967).

Key words: Annual report; technical highlights.

This is an illustrated digest of NBS technical and scientific activities during the fiscal year ending June 30, 1966. It lists major programs as they were carried out by the three NBS institutes: Institute for Basic Standards, Institute for Materials Research, and Institute for Applied Technology. Summaries are given of typical institute projects in applied mathematics, electricity, metrology, mechanics, heat, atomic physics, physical chemistry, laboratory astrophysics, radiation physics, radio standards, analytical chemistry, polymers, metallurgy, inorganic materials, reactor radiations, cryogenics, building research, information technology, instrumentation, radio propagation, engineering standards, and weights and measures. Also included are discussions of the Clearinghouse for Federal Scientific and Technical Information, the National Standard Reference Data System, Standard Reference Materials program, measurement services program, and national and international cooperative activities. This report also includes the description of the new laboratory facilities at Gaithersburg, Md., and the history of their construction.

M284. **Technology and world trade. Proceedings of a symposium held at the National Bureau of Standards, Gaithersburg, Md., November 16-17, 1966,** Editor, R. L. Stern, NBS Misc. Publ. 284 (1967).

Key words: Developing countries; international standards; role of government; role of private enterprise; technology; world trade.

The publication embodies the proceedings of the Symposium on Technology and World Trade, held on the occasion of the dedication of the new laboratories of the National Bureau of Standards at Gaithersburg, Maryland. Subjects considered by the 29 speakers and discussants from the United States, nine other nations, and the United Nations, include: Technology's Impact on the Character of World Trade and Investment; International Competition and Co-operation in Technology; The Role of International Standards; The Respective Roles of Government, Public and Private Enterprises in Creating, Using and Transferring Technology; and Technology in Relation to the Developing Countries.

M285. **Nuclear science and technology for ceramists. Proceedings of the American Ceramic Society Symposium, Washington, D.C., April 7-12, 1966,** NBS Misc. Publ. 285 (May 26, 1967).

Key words: Ceramics; lattice defects; nuclear fuels; nuclear science and technology; radiation damage; reactor materials.

An introductory survey is given on the subject of Nuclear Ceramics, consisting of six invited papers presented at an American Ceramic Society Symposium held in April, 1966. Authors and their titles are: C. O. Muehlhause (National Bureau of Standards) "Material Radiation Environment"; A. B. Lidiard (UK Atomic Energy Research Establishment, Harwell, England) "Radiation Damage in Ceramics"; P. W. Levy (Brookhaven National Laboratory) "Physical Properties of Irradiated Ceramic Materials"; R. J. Thorn and G. H. Winslow (Argonne National Laboratory) "Chemical Problems Associated with Lattice Defects"; D. W. Readey and J. H. Handwerk (Argonne National Laboratory) "Nuclear Fuel Materials"; and D. R. deHalas, W. D. Freshley, and W. C. Morgan (Pacific Northwest Laboratories, Batelle Memorial Institute) "Reactor Materials Design." The volume is intended to provide a survey of those properties involved in the choice and use of ceramics for nuclear technology, and as a reference useful in the teaching of ceramic science.

M286. **Units of weight and measure. International (metric) and U.S. customary,** L. J. Chisholm, NBS Misc. Publ. 286 (May 1967).

Key words: Conversion tables; International System (SI); Metric System; U. S. Customary System; weights and measures; weights and measures abbreviations; weights and measures systems; weights and measures units.

The primary purpose of this publication is to make available the most often needed weights and measures conversion tables--Conversions between the U. S. Customary System and International (Metric) System. A secondary purpose is to present a brief historical outline of the International (Metric) System--following it from its country of origin, France, through its progress in the United States. (Supersedes NBS Misc. Publ. 233).

M287. **Calculation of the properties of vacancies and interstitials. Proceedings of a conference, Shenandoah National Park, Va., May 1-5, 1966,** NBS Misc. Publ. 287 (Nov. 17, 1966).

Key words: Calculations; electronic states, energies of formation; energies of motion; interstitials; point defects; theory; vacancies; vibrational states.

This is the Proceedings of a Conference on the Calculation of the Properties of Vacancies and Interstitials. The Conference dealt with the theory and techniques of calculation of the properties of point defects in metallic and nonmetallic crystals. The contributed and invited papers divided about evenly among three major topics: (1) static-lattice calculations of the energies and configurations of simple vacancies and interstitials in, mainly, metals and ionic crystals; (2) electronic states at and near point defects in metals, rare gas solids, and insulators (*f*-centers, electron traps); and (3) vibrational states at point defects. The report of a panel discussion on each topic is also included. The emphasis is on the theory of the properties of isolated, simple defects rather than on the statistical properties of defect assemblies. The Conference attempted to examine the point defect theory and calculations critically, from the standpoint of general theory, rather than simply compare results with experiment.

M288. **Directory of United States standardization activities,** J. E. Hartman, NBS Misc. Publ. 288 (Aug. 1, 1967).

Key words: Certification and labeling plans; government standardization, U. S.; specifications; standardization activities, U. S.; standards; test methods.

The success of our nation's standardization program is due largely to the support given it by our national standardizing organizations. Some of these groups work toward establishing standards, while others develop test methods or certification and labeling plans to guarantee that products meet the specified standards. This Directory is a revision of NBS Miscellaneous Publication M230 "Standardization Activities in the United States" (1960). Work on the present edition began by questioning 1800 trade associations and standardizing groups in order to locate those undertaking a substantial degree of creative technical and engineering standardization. The Directory describes the activities of 486 American organizations engaged in standardization as a major or important part of their work. It includes a standardizing group for nearly all widely known product areas such as textiles, paper, leather, ceramics, plastics, electrical equipment, rubber, cement, etc. A comprehensive index provides quick reference to organizations and the fields, products, and services in which they specialize. (Supersedes NBS Misc. Publ. 230).

M289. **Bibliography of low energy electron collision cross section data,** L. J. Kieffer, NBS Misc. Publ. 289 (Mar. 10, 1967).

Key words: Atom; molecule; electron; collision cross section.

A bibliography of low energy electron collision cross section data is presented. Only references which report original measurements or calculations of electron collision cross sections are included. The cross section data for each process are listed by atomic species in order of their atomic number. The data for molecules are listed in arbitrary order.

M290. **Report of the 51st National Conference on Weights and Measures, 1966,** Report Editor, L. J. Chisholm, NBS Misc. Publ. 290 (May 15, 1967).

Key words: Conference, National; weights and measures.

A report of the proceeding of the fifty-first National Conference on Weights and Measures, held in Denver, Colorado, July 11, 12, 13, 14, and 15, 1966, and attended by state, county, and city weights and measures officials.

M291. **Proceedings of the 1966 Standards Laboratory Conference,** held at the National Bureau of Standards, Gaithersburg, Md., May 9-12, 1966, NBS Misc. Publ. 291 (July 13, 1967).

Key words: Accuracy; calibrations; conferences, 1966 Standards Laboratory; foreign standards laboratories; laboratory management; measurements and standards; measurement system; National Conference of Standards Laboratories; proceedings, 1966 Standards Laboratory Conference; traceability; United States measurement system.

The annual report of the NCSL chairman, and the text of 50 presentations on standards laboratory problems are given in this volume. The subjects treated at the third biennial congress of delegates of the National Conference of Standards Laboratories, held at the NBS Gaithersburg facility, May 9-12, 1966, included committee reports and panel discussions on the 1965-66 measurement agreement comparison, statistical control of the measurement process, information needs and sources, calibration procedures, the measurement system of USA, calibration needs of USA, personnel development, traceability and accuracy ratio, world-wide physical standards, equipment performance, organization and management, workload, and recommended practices.

M292. **Bibliography of Liesegang rings (Second Edition),** K. H. Stern, NBS Misc. Publ. 292 (Sept. 1, 1967).

Key words: Diffusion; Liesegang rings; periodic precipitation.

A bibliography of Liesegang rings (periodic precipitation figures produced by diffusion) and other periodic structures for the period 1855-1965 is compiled in chronological and alphabetical order. An author index and an index to applications of Liesegang rings to extra-chemical fields are also given.

M293. **Technical highlights of the National Bureau of Standards, Annual Report 1967,** NBS Misc. Publ. 293 (Nov. 1967).

Key words: Annual report; technical highlights.

This is an illustrated digest of NBS technical and scientific activities during the fiscal year ending June 30, 1967. It lists major programs as they were carried out by the three NBS institutes: Institute for Basic Standards, Institute for Materials Research, and Institute for Applied Technology. Summaries are given of typical institute projects in applied mathematics, electricity, metrology, mechanics, heat, atomic physics, physical chemistry, laboratory astrophysics, radiation physics, radio standards, analytical chemistry, polymers, metallurgy, inorganic materials, reactor radiations, cryogenics, building research, information technology, instrumentation, radio propagation, engineering standards, and weights and measures. Also included are discussions of the Clearinghouse for Federal Scientific and Technical Information, the National Standard Reference Data System, Standard Reference Materials program, measurement services program, and national and international cooperative activities.

M294. **Operations research. Proceedings of a conference for Washington area government agencies, April 20, 1966,** Editor, J. A. Joseph, NBS Misc. Publ. 294 (Dec. 1967).

Key words: Conference proceedings; government; operations research; systems analysis.

The proceedings of a one-day conference of practitioners and users of Operations Research in Federal Government in the Washington, D.C. area, sponsored by the National Bureau of Standards. The purpose of the conference was to initiate a series of periodic meetings where information on topics of actual concerns might be exchanged. Invited papers were presented by Prof. Merill M. Flood on "Operations Research in the Civilian Sector of the Government," Dr. John Haldi on "The Planning-Programming-Budgeting System," and Dr. Alan J. Hoffman on "Operations Research and Government O.R." Reports of two panel meetings on "Special Problems of Operations Research in Civil Agencies of Government" and "Broadening the O.R. Competence of Mid-Careerist" are included on the proceedings.

3.7. APPLIED MATHEMATICS SERIES

The Applied Mathematics Series contains mathematical tables, manuals and studies of special interest to physicists, engineers, chemists, biologists, mathematicians, computers and others engaged in scientific and technical work. Some of the volumes are reissues, to meet a continuing demand, of the Mathematical Tables 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 scientific sponsorship of and made available through the National Bureau of Standards. The Mathematical Tables series (MT) as originally issued is out of print; the list, by title, is given in NBS Circular 460.

When the Applied Mathematics Division was established at the National Bureau of Standards in July 1947, the Mathematical Tables Project became identified with the unit of this Division known as the Computation Laboratory. See "Price List of Available Publications", page 105.

AMS59. **Tables relating to Mathieu functions, Characteristic values, coefficients, and joining factors**, NBS Appl. Math. Series 59 (Aug. 1, 1967).

Key words: Characteristic values; coefficients; joining factors; Mathieu's equation.

This second edition of "Tables Relating to Mathieu Functions" (Columbia University Press, New York, 1951) incorporates the article "Table of Characteristic Values of Mathieu's Equation for Large Values of the Parameter" by Gertrude Blanch and Ida Rhodes, Journal of the Washington Academy of Sciences, Volume 45, No. 6, 166-196, June 1955, but makes no essential changes in tables or introductory material. However, a number of misprints in the first edition have been corrected and the bibliography updated. (A reissue, with additions, of Columbia University Press 13).

3.8. NATIONAL STANDARD REFERENCE DATA SERIES

This series provides quantitative data on the physical and chemical properties of materials, compiled from the world's literature and critically evaluated. Reports will fall into eight categories: general; nuclear properties; atomic and molecular properties; solid state properties; thermodynamic and transport properties; chemical kinetics; colloid and surface properties; and mechanical properties of materials. See "Price List of Available Publications," page 104.

NSRDS-NBS3, Section 2. **Selected tables of atomic spectra; atomic energy levels and multiplet tables;** Si I, C. E. Moore, NBS Natl. Std. Ref. Data Series 3, Section 2 (Nov. 30, 1967).

Key words: Atomic energy levels; atomic spectra Si I; first spectrum; multiplet table; silicon; spectrum, Si I; wavelengths, Si I.

The present publication is the second Section of a series being prepared in response to the increasing demand for a current revision of two sets of tables containing data on atomic spectra as derived from analyses of optical spectra.

Both the atomic energy levels and the multiplet table are included in the same publication, as parts A and B, respectively. The Sections are being prepared at irregular intervals for these spectra whose analyses are essentially complete. A flexible paging system permits the arrangement of the various Sections by atomic number regardless of the order in which the spectra are published in this series. Section 1 included three spectra of silicon, $Z=14$: Si II, Si III, Si IV. The present Section contains similar data for Si I. The form of presentation is described in detail in the text to Section 1, and need not be repeated here.

NSRDS-NBS5. **The band spectrum of carbon monoxide,** P. H. Krupenie, NBS Natl. Std. Ref. Data Series 5 (July 8, 1966).

Key words: Carbon monoxide; spectrum; review.

This is an exhaustive review of the literature and a critical compilation of the observed and predicted spectroscopic data on CO, CO^{+}, and CO^{2+} in the gas phase.

NSRDS-NBS6. **Tables of molecular vibrational frequencies, Part I,** T. Shimanouchi, NBS Natl. Std. Ref. Data Series 6 (Mar. 1, 1967).

Key words: Molecular; vibrational; frequencies; data; tables; force; constants; spectral.

A compilation of vibrational frequency data for selected molecules is being conducted at the University of Tokyo in cooperation with the National Standard Reference Data Program of the National Bureau of Standards as a part of an international effort to compile and evaluate physical and chemical data. This report, first of a series of annual reports, contains fundamental vibrational frequencies of 59 molecules together with vibrational assignments, sources of data, brief comments, and citations of references. The fundamental frequencies are obtained mainly from the infrared and Raman spectra. When these are not available, other experimental data such as microwave results are taken into account. The selection of vibrational fundamentals from observed spectral data is based upon careful studies of the spectral data and comprehensive mathematical analyses. These tables were designed to provide a concise summary needed for the computation of ideal gas thermodynamic properties. They may also provide a convenient source of information to those who require vibrational energy levels and related properties in molecular spectroscopy, analytical chemistry, and other fields of physics and chemistry.

NSRDS-NBS7. **High temperature properties and decomposition of inorganic salts. Part I. Sulfates,** K. H. Stern and E. L. Weise, NBS Natl. Std. Ref. Data Series 7 (Oct. 1, 1966).

Key words: Sulfates; thermodynamic functions; decomposition pressures.

The literature dealing with the high-temperature behavior of inorganic sulfates has been critically reviewed. Free energy functions of reactants and products of the decomposition reactions were calculated and have been tabulated from 298 °K up to as high a temperature as possible. Free energy functions, equilibrium constants of reactions, and partial pressures of gaseous components were tabulated. Auxiliary data on phase transitions, densities, and kinetics of chemical decomposition have also been included.

NSRDS-NBS8. **Thermal conductivity of selected materials,** R. W. Powell, C. Y. Ho, and P. E. Liley, NBS Natl. Std. Ref. Data Series 8 (Nov. 25, 1966).

Key words: Gases; liquids; metals; solids; thermal conductivity.

The data presented in this publication consists of the critical evaluation and analysis of the available thermal conductivity data on eleven metals and nine nonmetals for the solid state, on seven fluids for both the liquid and gaseous states and on two for the liquid state only. The materials studied were selected primarily for their potential applicability as reference standards or because of their technical importance. The temperature range for which values are given often exceeds that for which these values are known with a high degree of certainty.

NSRDS-NBS9. **Tables of bimolecular gas reactions,** A. F. Trotman-Dickenson and G. S. Milne, NBS Natl. Std. Ref. Data Series 9 (Oct. 27, 1967).

Key words: Activation energies; Arrhenius equation; bimolecular; chemical kinetics; data; gas; rate constants; reactions; tables.

This survey covers the kinetics of bimolecular and termolecular gas reactions that do not involve atoms or molecules in electronically excited states. Bimolecular reactions are here defined as reactions in which two molecules are involved as reactants, that yield two or more molecules as products. Those reactions in which two molecules combine to form one molecule are most usefully considered as the reverse of unimolecular reactions which will be dealt with in another survey. Reactions of oxygen and nitrogen atoms have been omitted as they will also form the subject of another survey.

The literature from 1954 to December 31, 1965 has been exhaustively searched and it is hoped that for this period nothing has been omitted that should have been included.

The survey of earlier work has been based on one of the writers' books on "Gas Kinetics" which covered the literature to 1954. Use of the book for over ten years has revealed few omissions and these have been included in these tables. Data for the period January to August 1966 has been included where possible.

NSRDS-NBS10. **Selected values of electric dipole moments for molecules in the gas phase,** R. D. Nelson, Jr., D. R. Lide, Jr., and A. A. Maryott, NBS Natl. Std. Ref. Data Series 10 (Sept. 1, 1967).

Key words: Dielectric constant; electric dipole moments; gas phase; microwave; microwave absorption; molecular beam; permittivity; refractive index; spectroscopy.

This table revises, brings up to date, and extends the coverage on numerical values for dipole moments which was included in NBS Circular 537, Tables of Dielectric Constants and Electric Dipole Moments of Substances in the Gaseous State, prepared by Maryott and Buckley in 1953. A recommended value with an estimate of accuracy is presented for more than five hundred organic and inorganic compounds. Extensive comments are given on the definition of dipole moment and principal methods of dipole moment measurement, as well as an exposition of the criteria employed in selecting the tabulated data. (Supersedes the data on dipole moments included in NBS Circ. 537).

NSRDS-NBS11. **Tables of molecular vibrational frequencies. Part II,** T. Shimanouchi, NBS Natl. Std. Ref. Data Series 11 (Oct. 1967).

Key words: Data; force constants; infrared spectra; modes of vibration; molecular vibrational frequencies; molecular spectra; Raman spectra.

A compilation of vibrational frequency data for selected molecules is being conducted at the University of Tokyo in cooperation with the National Standard Reference Data Program of the National Bureau of Standards as a part of an international effort to compile and evaluate physical and chemical data. This report, as a continuation of Part I published as NSRDS-NBS 6, contains fundamental vibrational frequencies of 54 molecules together with vibrational assignments, sources of data, brief comments, and citations of references. The procedures used for the preparation of tables are the same as given in Part I. The fundamental frequencies are obtained mainly from the infrared and Raman spectra. When these are not available, other experimental data such as microwave results are taken into account. The selection of vibrational fundamentals from observed data is based upon careful studies of the spectral data and comprehensive mathematical analyses. These tables were designed to provide a concise summary needed for the computaion of ideal gas thermodynamic properties. They may also provide a convenient source of information to those who require vibrational energy levels and related properties in molecular spectroscopy, analytical chemistry, and other fields of physics and chemistry.

NSRDS-NBS14. **X-ray wavelengths and X-ray atomic energy levels,** NBS Natl. Std. Ref. Data Series 14 (Sept. 25, 1967).

Key words: Absorption; atomic; data compilation; emission; energy levels; x-ray wavelength.

X-ray wavelengths, J. A. Bearden:

Inconsistencies in accepted values (in x units) of x-ray reference lines have recently been demonstrated, although all are supposedly based on "good" calcite crystals. Factors supporting the selection of the W $K\alpha_1$ line as *the X-Ray Wavelength Standard* are critically discussed. A review is given of the experimental measurements which are used to establish the wavelength of this line on an absolute angstrom basis. Its value is λ W $K\alpha_1$=(0.2090100±5 ppm) Å. This may be used to define a new unit, denoted by Å*, such that the W $K\alpha_1$ wavelength is exactly 0.2090100 Å*; hence 1Å=1Å±5ppm. The wavelengths of the Ag $K\alpha_1$, Mo $K\alpha_1$, Cu $K\alpha_1$, and the Cr $K\alpha_2$ have been established as secondary standards with probable error of approximately one part per million. Sixty-one additional x-ray lines have been used as reference values in a comprehensive review and reevaluation of more than 2700 emission and absorption wavelengths. The recommended wavelength values are listed in Å* units together with probable errors; corresponding energies are given in keV. A second table lists the wavelengths in numerical order, and likewise includes their energies in keV.

Reevaluation of X-ray atomic energy levels, J. A. Bearden and A. F. Burr:

All of the x-ray emission wavelengths have recently been reevaluated and placed on a consistent Å* scale. For most elements these data give a highly overdetermined set of equations for energy level differences, which have been solved by least-squares adjustment for each case. This procedure makes "best" use of all x-ray wavelength data, and also permits calculation of the probable error for each energy difference. Photoelectron measurements of absolute energy levels are more precise than x-ray absorption edge data. These have been used to establish the absolute scale for eighty-one elements and, in many cases, to provide additional energy level difference data. The x-ray absorption wavelengths were used for eight elements and ionization measurements for two; the remaining five were interpolated by a Moseley diagram involving the output values of energy levels from adjacent elements. Probable errors are listed on an absolute energy basis. In the original source of the present data, a table of energy levels in Rydberg units is given. Difference tables in volts, Rydbergs, and milli-Å* wavelength units, with the respective probable errors, are also included there.

3.9. BUILDING SCIENCE SERIES

Research results, test methods, and performance criteria of building materials, components, systems, and structures. See "Price List of Available Publications", page 104.

BSS9. **Thermal-shock resistance for built-up membranes,** W. C. Cullen and T. H. Boone, NBS Bldg. Sci. Series 9 (Aug. 21, 1967).

Section 1. Progress in the development of a thermal-shock resistance factor for bituminous built-up roofing membranes.

Key words: Development; roofing membrane; strength properties; thermally induced forces; thermal-shock resistance factor.

The resistance of bituminous built-up roofing membranes to thermally induced forces is considered in terms of their strength properties such as breaking load in tension, modulus of elongation and apparent linear thermal expansion coefficient. The development of a Thermal-Shock Resistance Factor is described and values are given for three bituminous built-up membranes at temperatures of -30 °F (-34.4 °C), 0 °F (-17.8 °C), 30 °F (-1.1 °C) and 73 °F (22.8 °C). The apparent relation between the values obtained in the laboratory and the observed performance of roofing membranes in service is considered. The utilization of the Thermal-Shock Resistance Factor in the reduction of potential failures of bituminous built-up roofing membranes in service from thermally induced forces is also discussed.

Section 2. Thermal-shock resistance for bituminous built-up roofing membranes--Its relation to service life.

Key words: Bituminous-built-up roofing; roofing membrane; service life; thermal-shock resistance factor; tension splitting.

The assignment of a service life to a bituminous built-up roofing system is frequently difficult because of the many variables involved. A knowledge of these variables, and of their effect on the performance of the total building system, will greatly assist in the selection of a roofing assembly and the assignment of a service life to such an assembly.

Some of the factors such as breaking load in tension, modulus of elongation, and apparent linear thermal expansion coefficient of roofing membranes of different composition are given for both laboratory-prepared and field-obtained samples. Membranes of 2, 3, and 4-plies of felt are included. The relations of some engineering properties of a roofing membrane to performance in sevice as expressed by a Thermal-Shock Resistance Factor are also given. Ways and means to reduce potential failures of bituminous built-up roofing membranes resulting from thermally induced forces are discussed.

BSS10. **Field burnout tests of apartment dwelling units,** D. Gross, NBS Bldg. Sci. Series 10 (Sept. 29, 1967).

Key words: Apartment dwelling; burnout test; fire load; fire performance; flame penetration; potential heat; structural load.

Results are reported of three burnout tests in an experimental test building, using a wood crib fuel load of 6 lb/ft^2, representing combustible contents, and a structural design load of 40 lb/ft^2 applied to the floor or roof above the test room. Measurements were made of temperature, radiation, smoke, gas composition, and structural deflection. A discussion of the fire performance of materials and methods of construction, and conclusions with regard to specific fireprotective objectives are presented.

BSS11. **Fire resistance of steel deck floor assemblies,** H. Shoub and S. H. Ingberg, NBS Bldg. Sci. Series 12 (Dec. 1967).

Key words: Burnout tests; fire endurance; fire severity; floor tests; steel plate floors.

Tests were conducted to determine the resistance to fire of welded steel plate and beam floor assemblies with various conditions of floor covering on the plates, and ceiling protections beneath the beams. The trials included fire exposures from the burnout of combustible materials ranging from 10 to 40 lb/ft^2 on the floor surface as well as standard fire endurance tests in which the ceiling of the structure was exposed to fire.

The results of the tests indicated that the use of steel floor structures was practical from considerations of fire safety. For the test conditions established, fire exposure on top of the floor did not heat the structural steel supporting members sufficiently to cause load failure or collapse, and did not produce untenable conditions in the room below. In tests involving fire exposure to the underside of floors, the fire endurance times, based solely on heat transmission criteria, ranged from 1 hr 24 min to over 4 hr. Temperature levels attained by the structural members and deflection of the floor assemblies are also reported.

BSS12. **Performance of square-edged orifices and orifice-target combinations as air mixers,** T. K. Faison, Jr., J. C. Davis, and P. R. Achenbach, NBS Bldg. Sci. Series 12 (Nov. 24, 1967).

Key words: Diameter ratio; mixing effectiveness; square-edged orifice; temperature measurement; temperature pattern.

A study was made at the National Bureau of Standards to determine the effectiveness of the square-edged orifice, or the orifice in combination with a target (circular baffle), for mixing an air stream which was initially nonuniform with respect to temperature. By achieving uniformity of temperature at all points within the cross section of an air stream, instrumentation for measurement might be simplified and a more representative temperature value obtained. Orifices having throat diameters of 8, 12, and 16 in were evaluated in a 24-in circular test duct to determine mixing effectiveness under selected test conditions of temperature distribution and flow rate. Targets of 8, 12, and 16 in in diameter in combination with a 12-in orifice were also investigated under similar conditions.

Graphic material is presented which illustrates how the orifice and orifice-target combinations perform as mixing devices under selected conditions. Results indicate that the 8-in (0.33 diam ratio) orifice effectively diminished the nonuniformity of temperature but only at a high pressure drop across the orifice and that a distance of 4.5 duct diameters was required for mixing.

3.10. COMMERCIAL STANDARDS

This series define the quality levels for products in accordance with the principal needs of the trade. Their use is voluntary. See "Price List of Available Publications", page 105.

CS188-66. **Cast iron soil pipe and fittings,** NBS Comm. Std. 188-66 (July 1, 1966).

Key words: Cast iron pipe, requirements; soil pipe and fittings; soil pipe dimensions.

This standard covers pipe and fittings of the following patterns and, when so designated, may apply to any other patterns that conform with the requirements given therein. (Supersedes CS188-59).

CS236-66. **Mat-formed wood particleboard,** NBS Comm. Std. 236-66 (Apr. 15, 1966).

Key words: Mat-formed particleboard; particleboard requirements; particleboard, wood; wood particleboard.

This Commercial Standard covers two types of mat-formed wood particleboard; one for interior applications and one for certain exterior applications in addition to interior applications. Each type is further divided into several density grades which are subdivided into strength classifications. It is intended that the applications of the products will be consistent with the properties of the respective density grades and strength classifications described. Also included are definitions, dimensional tolerances, test methods, inspection practices, and methods of marking and certification to identify products that comply with all requirements of this Standard. (Supersedes CS236-61).

CS251-63. **Hardboard,** NBS Comm. Std. 251-63 (Nov. 15, 1966).

Key words: Fiber board; hardboard; ligno-cellulosic fibers; and lignin and hot pressed fibers.

This standard sets forth the standard commercial types, and sizes of hardboard, and gives information on special hardboards available. It provides specifications for physical requirements and test methods for static bending (modulus of rupture), tensile strength, water absorption, and thickness swelling. It includes a glossary of terms used in the hardboard industry, and recommends a uniform means of marking and certifying for the consumer hardboards that comply with this Standard. (Reprinted April 1967 with Amendments effective November 15, 1966).

CS274-66. **TFE-fluorocarbon (polytetrafluoroethylene) resin sintered thin coatings for dry film lubrication,** NBS Comm. Std. 274-66 (Jan. 20, 1966).

Key words: Coatings, dry film; dry film lubrication; polytetrafluoroethylene; resin sintered coatings; and TFE-fluorocarbon.

This standard establishes the requirements and methods of test for the material, thickness, workmanship, and properties of TFE-fluorocarbon resin coatings 0.001 inch or less in thickness for the purpose of dry film lubrication. Methods of marking and indicating compliance with this standard are included.

3.11. SIMPLIFIED PRACTICE RECOMMENDATIONS

This series list the staple sizes, kinds, types, and applicable methods for certain commodities produced and stocked in greatest quantity, to aid in holding variety to a minimum. Their use is voluntary. See "Price List of Available Publications", page 105.

SPR174-65. **Cast-iron radiators,** NBS Simpl. Prac. Recomd. 174 65 (Dec. 31, 1965).

Key words: Cast iron radiators; radiators, cast iron; radiator ratings; radiator sizes.

This recommendation covers sizes, types and dimensions of radiators, stock assemblies and general provisions. It does not cover baseboard type of radiation. (Supersedes SPR174-47.)

3.12. PRODUCT STANDARDS

This series provide requirements for sizes, types, quality and methods for testing various industrial products. These standards are developed cooperatively with interested Government and industry groups and provide the basis for common understanding of product characteristics for both buyers and sellers. Their use is voluntary. (Replaces the Commercial Standard Series and Simplified Practice Recommendations.) See "Price List of Available Publications", page 105.

PS1-66. **Softwood plywood, construction and industrial,** NBS Prod. Std. 1-66 (Nov. 1, 1966).

Key words: Adhesives; boil test; bonding; exterior; grading; interior; moisture content; overlay; plywood; shear test; vacuum and pressure test.

This Product Standard covers the principal types, grades and sizes of plywood. Requirements are specified for wood species, veneer grading, overlays, glue bond, panel construction, moisture content, dimensions and tolerances, as well as sampling and inspection procedures, test methods to determine compliance, and a glossary of trade terms and definitions. A quality certification program is provided for herein, whereby qualified testing agencies inspect, sample and test products identified as complying with this Standard. (Supersedes CS45-60, CS122-60, and CS259-63).

PS2-66. **Standard sizes of blackboard slate,** NBS Prod. Std. 2-66 (May 15, 1966).

Key words: Blackboards; dimensions; natural markings; slabs; slate; standard sizes; thickness; tolerances.

This recommendation covers dimensions for blackboard slabs and dimensions of blackboard slates for other than wall use. Also included are requirements for thickness, finish, and color and imperfections of natural slate. (Supersedes SPR15-35).

PS3-66. **TFE-fluorocarbon (polytetrafluoroethylene) resin skived tape,** NBS Prod. Std. 3-66 (Sept. 1, 1966).

Key words: Electrical tape, plastic; plastic tape; polytetrafluoroethylene; resin skived tape; skived tape; TFE-fluorocarbon.

This standard establishes requirements and methods of test for the material, dimensions, workmanship, and the physical and electrical properties of three grades of skived tape manufactured entirely of TFE-fluorocarbon resin in accordance with good commercial practice. The materials covered range in thickness from 0.002 inch to 0.125 inch, and are normally manufactured by skiving.

PS4-66. **Standard stock light-duty 1 3/8- and 1 3/4-inch thick flush-type interior steel doors and frames,** NBS Prod. Std. 4-66 (Nov. 1, 1966).

Key words: Interior steel doors; standard interior steel doors; steel door frames, steel doors, interior.

This Product Standard covers sizes, types, materials, construction, hardware installation, and finishing of the doors, frames, and accessories. They are intended to be stock items for use in light-duty applications where low cost flush doors are desired. The standard also provides a uniform method of marking, identifying, and labeling. (Supersedes CS211-57).

PS5-66. **Porcelain enameled formed steel plumbing fixtures,** NBS Prod. Std. 5-66 (Nov. 1, 1966).

Key words: Abrasion resistance; chemical resistance; porcelain enamel; sanitary ware; sheet steel.

The standard covers materials, dimensions, construction and methods of inspection, testing, and labeling. Definitions are given for certain trade terms. The types and sizes of fixtures in general use and demand are listed for bathtubs, lavatories, kitchen sinks and sink-and-laundry-tray combinations. (Supersedes CS144-47).

PS6-66. **Trim for water-closet bowls, tanks and urinals (dimensional standards),** NBS Prod. Std. 6-66 (Nov. 1, 1966).

Key words: Bowls; brass; dimensions; nuts; plastic; plumbing equipment; tanks; valves.

The purpose of this standard is to establish a basis for dimensional interchangeability for those items of trim for water-closet bowls, tanks and urinals known as spuds, lock nuts for spuds, flush valves for staple low tanks, float valves, flush elbows, and coupling nuts. It is also intended to provide a basis for understanding between buyers and sellers for the dimensions and tolerances that govern the fit of trim in the fixtures and connecting parts of trim. (Supersedes CS172-50).

PS7-66. **Wire bar supports for reinforced concrete construction,** NBS Prod. Std. 7-66 (Aug. 1, 1966).

Key words: Bars, concrete reinforcement; concrete construction, supports; reinforced concrete construction; reinforcement bars; wire bar supports.

The standard lists twelve types of wire bar supports and the sizes of each in greatest demand. The minimum size of wire is given for each type of bar support. Maximum spacings at which the bar supports will function properly in ordinary slabs, joists, beams, and girders are included. The standard also lists a number of modifications of the standard bar supports for special applications in concrete reinforcement, which are not regularly stocked but may be obtained as standard items when specified.

PS8-67. **Grading of abrasive grain on coated abrasive products,** NBS Prod. Std. 8-67 (Jan. 9, 1967).

Key words: Abrasive grain; accumulation curve; coated abrasive products; grain, abrasive; micron; overgrade; sedimentation; sieve; standard sieve.

The scope of this Product Standard is confined to a determination of the grit sizes of the abrasive grain on the coated product. However, the information may also be of use in the preparation of abrasive grain for making coated abrasive products. It has been developed to cover, insofar as possible, the grading of the grit sizes of abrasive grain on the standard coated abrasive products listed in Simplified Practice Recommendation R89-55. (Supersedes CS217-59).

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3.13. TECHNICAL NOTES

This series was initiated in 1959 to supplement the Bureau's regular publications program. Technical Notes provide a means for making available scientific data that are of transient or limited interest. See "Price List of Available Publications", page 106.

TN100-A, Supplement to Appendix C of TN100. **Loading factors and FDM-FM system performance calculations,** E. F. Florman, NBS Tech. Note 100-A (Sept. 1967).

Key words: Modulators; radio communications; radio receivers; transistors.

This supplement was written for the purpose of extending the scope of the original paper, by providing a more complete set of system-performance design equations, which apply to the Frequency Division Multiplex--Frequency Modulation type of multichannel telecommunication systems; these equations may be used for various types, and combinations of types, of message signals.

TN213. Unassigned.

TN246. **A survey of some empirical and semi-empirical interatomic and intermolecular potentials,** B. N. Axilrod, NBS Tech. Note 246 (Oct. 3, 1966).

Key words: Atoms; compressibility; heat of sublimation; molecules; potential functions; empirical and semi-empirical; transport properties; virial coefficients.

Many empirical and semi-empirical potential functions have been proposed or developed to represent the pairwise interaction of atoms and molecules. The simple pair potentials proposed usually contain parameters to be adjusted to fit certain properties, for example, when chemical combination does not occur, virial coefficients and similar quantities for the gaseous state, or compressibility and heat of sublimation for the crystalline state. In the present survey a number of potentials proposed recently are examined to indicate the variety of concepts employed and the suitability of the potential functions.

TN277. **Analytical Mass Spectrometry Section: instrumentation and procedures for isotopic analysis,** Edited by W. R. Shields, NBS Tech. Note 277 (July 25, 1966).

Key words: Mass spectrometry; instrumentation; procedures; isotopic analysis.

This report describes the general instrumentation of the Analytical Mass Spectrometry Section and the specific analytical techniques which have been devised for the measurement of isotopic ratios of Ag, Br, Cl, Cr, Cs, Cu, Mg, Pu, and U. Interim procedures for B, Li, Rb, and Sr are also given.

In the appendix some general statistical principles used in the design and analysis are briefly discussed; an example is given in detail illustrating the various steps involved leading from original data to the reported uncertainties for the isotopic ratio of bromine.

TN278. **Scanning electron probe microanalysis,** K. F. J. Heinrich, NBS Tech. Note 278 (Feb. 3, 1967).

Key words: Electron probe; microanalysis; x-ray spectrometry; scanning electron microscopy; electron backscatter; cathodoluminescence.

The combination of electron microprobe x-ray emission spectrometry with the scanning techniques first developed for the scanning electron microscope permits using the scanning electron probe as a microscope sensitive to elemental composition. This technique is particularly useful in the many applications in which spatial distribution of one or more elements in a specimen is more important than local composition. Although oscilloscope representation of probe scanning is usually obtained by the simple technique of producing a dot of light for each arriving photon, more sophisticated scanning techniques such as expanded contrast registration and concentration mapping can provide more quantitative information. Signals other than x-rays, such as target current, electron backscatter, or cathodoluminescence may be used for image formation. Electron beam scanning can also be performed in a discontinuous fashion, so that the electron beam irradiates in succession a number of spots arranged in a square or rectangular pattern, and the number of photons registered in each position is retained in the memory of a multichannel analyzer. The application of these diverse scanning techniques is illustrated.

TN292. **Procedures for precise determination of thermal radiation properties, November 1964 to October 1965,** J. C. Richmond, G. J. Kneissl, D. L. Kelley, and F. J. Kelly, NBS Tech. Note 292 (Feb. 10, 1967).

Key words: Emissivity; emittance; high temperature reflectance; infrared reflectance; radiation properties; reflectance; spectral emittance; spectral reflectance; thermal radiation; total emittance.

The broad overall objective of this continuing program is to develop equipment and procedures for measuring the important thermal radiation properties of materials, particularly those used in aircraft, missiles, and space vehicles, at temperatures up to the melting point of the most refractory material, and to develop physical standards for checking such equipment and procedures. During the period covered by this report the specific objectives were: (1) continued development of the laser-source integration sphere reflectometer, (2) an error analysis of the shallow cavity technique for measuring normal spectral emittance, and (3) a study of the feasibility of preparing emittance standards for use at temperatures above 1400 °K (about 2000 °F).

An error analysis of the shallow cavity technique for measuring total normal emittance of ceramic materials at very high temperatures showed that there was an error due to the translucency of the specimens that was as much as +60% for alumina, and a second error due to thermal gradients in the specimen that was on the order of -10%. Two new techniques were devised in the hope of greatly reducing the translucency error. Progress was made in developing codes to compute and correct for the thermal gradients present in the specimen. The laser-source integrating sphere reflectometer for measuring reflectance of specimens at very high temperatures was extensively redesigned to eliminate errors due to flux reaching the detector on the first reflection, and to convert the reflectometer from the substitution to the comparison mode. A literature search was made of techniques for measuring thermal radiation properties of solids at temperatures above 2500 °K (4000 °F).

TN293. **Research on crystal growth and characterization at the National Bureau of Standards, June 1966,** Editor, H. C. Allen, Jr., NBS Tech. Note 293 (Aug. 26, 1966.)

Key words: Crystal growth; crystal characterization; crystalline materials.

The National Bureau of Standards with partial support from the Advanced Research Projects Agency of the Department of Defense is continuing a wide program of studies involving crystalline materials. These include investigation of methods and theory of growth, study of detection and effects of defects, determination of physical properties, refinement of chemical analysis, and determination of stability relations and atomic structure. The types of materials range from organic compounds, through metals, and inorganic salts to refractory oxides. This report summarizes progress in those projects wholly or partially supported by ARPA.

TN294. **Notes on the state-of-the-art of benefit-cost analysis as related to transportation systems,** J. D. Crumlish, NBS Tech. Note 294 (Nov. 1, 1966).

Key words: Benefit-cost analysis; transportation economics; transport systems; systems analysis; state of the art.

This review of benefit-cost analysis as a tool for evaluating alternative courses of action describes the technique, discusses a number of benefit-cost studies, and indicates the difficulties inherent in this area of applied economics. The author concentrates on the application of the technique to large scale transport problems, reviews the literature and indicates in his conclusions where the technique can be helpful and where there is little chance for its success.

An accompanying matrix of benefit-cost studies and a commentary thereon is supplied by Marsha Geier, an NBS economist. Miss Geier's literature search failed to produce any analytic methods which were comprehensive, theoretically justifiable, operational or significant. This finding tended to support the views of the author. (Introduction by Alan J. Goldman, Applied Mathematics Division, Institute for Basic Standards, National Bureau of Standards.)

TN295. **Disclosures on: A transrotor engine; high temperature platinum resistance thermometer; dynamic analog correlation system; and combination metering and safety valve for filling sonde balloons with hydrogen,** Editors, D. Robbins and A. J. Englert, NBS Tech. Note 295 (Oct. 21, 1966).

Key words: Transrotor engine; platinum resistance; dynamic analog correlation system; combination metering and safety valve; high temperatures.

This note presents descriptions and drawings of four devices, embodying interesting and unusual solutions to problems frequently encountered in their respective fields: a transrotor engine, a dynamic analog correlation system, a high temperature platinum resistance thermometer, and a combination metering and safety valve for filling sonde balloons with hydrogen.

Other disclosures on various subjects may be found in NBS Technical Notes 237, 253, 263, 282, and 287.

TN296. **A grammar for component combination in Chinese characters,** B. K. Rankin, III, S. Siegel, A. McClelland, and J. L. Tan, NBS Tech. Note 296 (Dec. 1966).

Key words: Chinese characters; grammar; generative grammar; component combination; phrase structure grammar; linguistics; frame embedding; two-dimensional languages.

A linguistic analysis of one aspect of the structure of Chinese characters is presented. The analysis is an extension into two dimensions of a general approach to one-dimensional language study. Results of the analysis are in the form of a three-level generative grammar. The first level formalizes restrictions governing the general complexity of well-formed Chinese characters; the second level formalizes co-occurrence constraints among character components and the particular spatial arrangement of these components in classes of characters; the third level constitutes a procedure for selecting actual components from a lexicon. Finally an evaluation of the grammar is presented, in terms of criteria used in evaluating natural language grammars.

TN297. **Evaluation of information systems: A selected bibliography with informative abstracts,** M. M. Henderson, NBS Tech. Note 297 (Dec. 1967).

Key words: Effectiveness; evaluation; performance; relevance; testing of information systems.

A survey of the literature on evaluation of information systems has been conducted by the Technical Information Exchange, Center for Computer Sciences and Technology, National Bureau of Standards. During the early stages of the survey, the literature was divided among descriptions of programs which compared the performance of two or more information systems, accounts of programs which studied the performance of one system, papers and reports which discussed the problems of evaluation programs, and documents which proposed new techniques for evaluation of systems. From the total literature collected, those references which were judged to be most directly concerned with the subject of evaluation of information systems were selected and abstracted. The abstracts are designed to give a summary of the content of the corresponding paper; the author's own wording was used extensively, in order to avoid misinterpretation. All of the references collected are listed, in alphabetic order of authors' names, in the appendix to the main body of this publication.

TN298. **A survey of ionization vacuum gages and their performance characteristics,** W. G. Brombacher, NBS Tech. Note 298 (Feb. 3, 1967).

Key words: Bayard-Alpert gages; cold cathode vacuum gages; conductance pressure dividers; hot cathode vacuum gages; ionization gages; vacuum gage calibration systems; vacuum gages; volumetric pressure dividers.

The design of various types of ionization gages is outlined, with particular attention to the design elements important to performance. The performance and the many factors affecting the performance of the various gages are reviewed. Methods of calibration are discussed in some detail, including the use of volumetric pressure dividers, conductance pressure dividers and constant rate of pressure change methods. About 365 references to the literature are cited.

TN299. **Calculation of the heating value of a sample of high purity methane for use as a reference material,** G. T. Armstrong, NBS Tech. Note 299 (Dec. 15, 1966).

Key words: Methane; heating value; heat of combustion; reference material; gross heating value.

The heat of combustion of CH_4 has been recalculated in kJ $(mol)^{-1}$, Btu $(mol)^{-1}$, Btu $(cu\ ft)^{-1}$ (dry basis) and Btu $(std.\ cu\ ft)^{-1}$ (saturated basis), using the best available experimental determinations of the heat of combustion and other measured quantities and the most recent generally accepted physical constants and defined physical units. The calculations are outlined in detail. The resulting quantities are applied to calculation of the heat of combustion of a reference sample of CH_4 submitted for analysis of composition and certification of heating value by the Institute of Gas Technology.

TN338. Unassigned.

TN339. **Observed phase-front distortion in simulated earth-to-space microwave transmissions,** H. B. Janes and M. C. Thompson, Jr., NBS Tech. Note 399 (May 12, 1966).

Key words: Atmospheric; distance measurements; earth-to-space microwave transmissions; microwave transmissions; phase; tracking.

An experimental study has been made of the time and space statistics of the phase-front distortion of microwave signals sent from a ground terminal to an elevated terminal. These phase-front characteristics are important in systems involving phase measurements between a ground station and a moving air-borne or space terminal. To isolate atmospheric errors from random motion of the upper terminal, the latter was simulated by a series of mountaintop antenna arrays. Phase-front distortion was analyzed in terms of time variations in radio range on a single path and in first and second range differences from pairs of paths. The cross-correlations of (1) range variations on adjacent paths, and (2) range difference variations on both adjoining and separated pairs of paths are investigated, including the strong dependence of correlation on the portion of the power spectrum included in the data. The effect of the mountaintop terrain on the spatial homogeneity of the phase-front was examined and found to be insignificant. A diurnal pattern in the variance of 15-minute range difference samples was observed, with minimum variance in the early morning hours. This pattern was not observed in the range variances, nor were the range and range difference variances significantly correlated with refractive index, air temperature, pressure or wind speed data at the lower terminal.

TN340. Unassigned.

TN341. **The long-term performance of two rubidium vapor frequency standards,** B. E. Blair and A. H. Morgan, NBS Tech. Note 341 (June 22, 1966).

Key words: Aging; calibration (USFS); frequency standards; gas cells; performance (long term); reliability; rubidium; stability.

Since mid-1961 the National Bureau of Standards has used two rubidium vapor frequency standards as transfer or Working Frequency Standards (WFS). The WFS provides a continuously available frequency which is periodically calibrated in terms of the United States Frequency Standard (USFS). This paper evaluates these calibration data over a 44.5-month period of time. It gives the long-term performance of the rubidium standards in terms of the USFS, compares them with a commercial cesium-beam frequency standard, and presents their reliability characteristics as shown by the mean-time-between-failures (MTBF). The calibration data are graphed with applicable tolerance limits for the between-adjustment periods. The average standard error of estimate about least squares lines fitted to the frequency data is about 2 parts in 10^{11}. The rubidium standards also show a rather consistent daily aging rate of parts in 10^{13}. This would indicate that the frequency of either unit would change a few parts in 10^{10} if operated continuously for one year without any frequency adjustments.

TN342. **Hydromagnetic wave propagation near 1 c/s in the upper atmosphere and the properties and interpretation of pc 1 micropulsations,** J. A. Dawson, NBS Tech. Note. 342 (June 30, 1966).

Key words: Alfven; dispersion; hydromagnetic; magnetosphere; multicomponent; pc 1 micropulsations; plasma; polarization; propagation.

Part I. Hydromagnetic wave propagation near 1 c/s in the upper magnetosphere: Dispersion and polarization relations are developed from basic considerations for a hydromagnetic wave at about 1 c/s propagating in a cold uniform plasma. The treatment is then extended to include the effects of ion-electron collisions. It is shown that the approximations used are valid in the earth's magnetosphere for heights between 10,000 and 50,000 km (2.6 to 8.8 earth radii). At lower elevations the plasma must be considered as nonuniform. Above 50,000 km the small amplitude assumption is invalid. Finally the theory is extended to include the effects of a multicomponent plasma.

Part II. The properties and interpretation of pc 1 micropulsations: A reasonable hydromagnetic model for the propagation of pc 1 micropulsations is one in which Alfven (left-hand) waves travel along field lines to reach the earth's surface at auroral latitudes and then propagate equatorward as modified Alfven (right-hand) waves just above the ionosphere. The isotropic right-hand wave is constrained to a duct between 400 and 2000 km above the earth by refractive processes. It is shown how many of the observed properties of pc 1's can be related to such a model. Mechanisms for the generation of pc 1's are also discussed and it is concluded that particle instabilities are the most likely source.

TN343. **Temperature-entropy diagram for parahydrogen triple-point region,** C. F. Sindt and D. B. Mann, NBS Tech. Note 343 (June 22, 1966).

Key words: Enthalpy; entropy; parahydrogen; pressure-volume; properties; temperatures; triple-point region; T-S diagram.

The three-phase region at and near the triple point of parahydrogen is presented on the graphical coordinates of temperature and entropy. Isobars from 10 mm Hg to 340 atmospheres, temperatures from 11° to 23 °K and specific volumes covering the range of from 10.5 cc/gm to 15,000 cc/gm are included. The energy base of enthalpy and entropy are consistent with previous data published by this laboratory.

TN344. **A sensitive recording NMR ultrasonic spectrometer,** L. W. James, NBS Tech. Note 344 (Sept. 7, 1966).

Key words: Boxcar integrator; nuclear magnetic resonance; phonon nuclear interaction; ultrasonics.

Instrumentation is described for automatically obtaining a continuous recording of ultrasonic absorption lines. Ultrasonic power is added to the crystal lattice by a transducer mounted on a single crystal of the sample. The interaction of the ultrasonics with the nuclear spin system is recorded by using a pulse NMR system in conjunction with a boxcar integrator. This technique is more sensitive and provides more easily interpretable results than earlier systems.

TN345. **A new near-zone electric field-strength meter,** F. M. Greene, NBS Tech. Note 345 (Nov. 15, 1966).

Key words: Device, electro-explosive ordnance; field, near-zone electromagnetic; hazards, electromagnetic radiation; line, non-metallic electrical transmission; line, semi-conducting plastic transmission; meter, electric field-strength; telemetry, novel form of.

The National Bureau of Standards has recently completed the development of prototype instrumentation for measuring the electric-field components of complex, high-level, near-zone electromagnetic fields from 0.1 to 1000 volts per meter, at frequencies from 150 kHz to 30 MHz with a present uncertainty of less than ±2 dB. The design of the NBS meters is based on the use of a novel form of telemetry, employing a completely non-metallic electrical transmission line, which apparently has not been fully exploited heretofore. This avoids the perturbing effects on the field being measured, usually caused by field-strength meters employing metallic RF transmission lines. The design and performance of the meter are discussed in some detail.

TN346. **On the natural shift of a resonance frequency,** R. J. Harrach, NBS Tech. Note 346 (Sept. 29, 1966).

Key words: Atomic beam; frequency shift; radiation field; resonance; thallium.

The natural resonance frequency shift, caused by the transition-inducing radiation field, is examined for a magnetic dipole transition between hyperfine structure levels in the ground state of a thallium atom. A calculation predicts, for an atomic beam experiment, a natural shift magnitude of 1.4 parts in 10^{10} of the thallium resonance frequency, per mW/Oe. In the experiment, frequency shifts caused by overlap of neighboring resonances were observed, but the natural shift was unresolved, indicating that its size is more than an order of magnitude below the calculated value. Subsequently it has been shown that the natural shift was inhibited by the particular radiation field mode used in the experiment. When the theory correctly takes this mode into account, the calculated natural frequency shift is consistent with the experimental results.

TN347. **A standard for accurate phase-angle measurements at audio frequencies,** W. W. Scott, Jr., NBS Tech. Note 347 (Oct. 14, 1966).

Key words: Phase-angle; standard; audio frequency; thermal voltage converter; inductive voltage divider; measurement.

A method is described for the measurement of phase angles from 0 ° to 360 ° (except for a band ±10 ° about the 180 ° point) with an uncertainty at audio frequencies of ±0.05 ° to ±0.01 °, depending on the phase-angle. The method utilizes readily available equipment which may be assembled and connected to serve as a standard. The principal advantage of this standard is in its potentially broad frequency-response; namely, 10 Hz to 10 kHz or higher. It makes use of inductive voltage dividers and thermal voltage converters to compare voltage magnitudes, which are related to phase-angle by the law of cosines. The thermal voltage converters are compared with each other before each phase-angle measurement. Their outputs are connected so that short-time power supply variations do not affect the measurements. The repeatability of measurements with this standard at a phase-angle of 60 ° is within a range of 0.001 °.

A model has been built which shows good measurement precision, but it has not been thoroughly tested or studied at many frequencies and phase-angles for sources of error. This report serves as a record of the development work completed on this standard to date.

TN348. **Infrared reflectances of metals at cryogenic temperatures —a compilation from the literature,** P. F. Dickson and M. C. Jones, NBS Tech. Note 348 (Oct. 14, 1966).

Key words: Compilation; cryogenic; infrared; metals; reflectance.

Spectral and total reflectances for metals at cryogenic temperatures in the infrared wavelength region are compiled from the literature. Information concerning sample preparation and purity, radiation source, and methods of reflectance measurements are also presented. Observations regarding the effects on reflectance of temperature, oxide layer, wavelength, and sample preparation are given.

TN349. **The design and operation of a high-voltage calibration facility,** W. W. Scott, Jr., NBS Tech. Note 349 (Nov. 10, 1966).

Key words: Alternating-current; calibration; direct-current; high-voltage; ratio; safety; standards enclosure; transformer; voltage-divider; voltmeter.

The high-voltage calibration facility, in operation for seven years at the National Bureau of Standards Radio Standards Laboratory (RSL) but now at NBS Washington, is described with emphasis on several novel construction features and calibration techniques. The more usual calibration techniques are also outlined for the assistance of those personnel in standards laboratories assigned the task of calibrating with high accuracy, electrostatic voltmeters, resistive dividers, and potential transformers at high voltage. Precautions, based on experience in the calibration and use of high voltage standards, are given so that certain errors may be avoided by the users.

TN350. **The viscosity and thermal conductivity coefficients of dilute nitrogen and oxygen,** G. E. Childs and H. J. M. Hanley, NBS Tech. Note 350 (Oct. 31, 1966).

Key words: Dilute gases; nitrogen; oxygen; transport coefficients; Lennard-Jones; Kihara; Exp: 6; Morse potential functions; Eucken correction; correlation.

The coefficients of viscosity and thermal conductivity for dilute nitrogen and oxygen were examined using a method proved suitable for argon. Given the kinetic theory expressions for the transport coefficients, this method indicates a selection of a potential function and its parameters to correlate theory with experimental data. The potential functions chosen were the Lennard-Jones, Kihara, Exp: 6 and the Morse. It was found that the Kihara was most suitable and theoretical viscosity coefficients were computed with this function. The usual correction to the kinetic theory equation for thermal conductivity, the Eucken correction, was found not to be sufficient and it was decided to use an empirical polynomial equation to correlate the thermal conductivity coefficients. Tables of the transport coefficients for both gases are given between 100 and 1000 °K.

TN351. **Discussion of errors in gain measurements of standard electromagnetic horns,** R. W. Beatty, NBS Tech. Note 351 (Mar. 1967).

Key words: Antennas; calibration; comparison; effective aperture; electromagnetic horns; gain; measurement; microwave; mismatch errors; Rayleigh distance; standard gain horns.

In setting up a calibration service for measuring the gain of standard electromagnetic horns, one needs a reference horn in which one has developed a high degree of confidence. Although it is possible to calculate the gain of horns of certain design, confidence can be increased by carefully measuring the gain. This note examines a method for measuring the gain of two identical horns, listing the assumptions made in making such a measurement. The theory of 2-port waveguide junctions is applied to the analysis of the measurement technique. The method is shown to be essentially an attenuation measurement which has additional sources of error. Although these errors are not analyzed and evaluated in this note, the problem is perhaps more clearly stated than it was previously. The mismatch error in comparing two horns as receiving antennas is analyzed. Data is given on the aperture efficiency of standard horns which indicates that improvements in the design of such horns are feasible. It is concluded that, at present, an uncertainty limit of the order of tenths of decibels seems realistic, but hundredths of decibels seems unattainable until further refinements are made both in the standard horns themselves and in the measurement techniques.

TN352. **The viscosity and thermal conductivity coefficients of dilute neon, krypton, and xenon,** H. J. M. Hanley and G. E. Childs, NBS Tech. Note 352 (Mar. 23, 1967).

Key words: Dilute gases; neon; krypton; xenon; transport coefficients; correlations; m-6; Kihara; Exp: 6, Morse; potential functions.

The coefficients of viscosity and thermal conductivity for dilute neon, krypton, and xenon were examined by a method already proved successful for dilute argon, oxygen, and nitrogen. This method selects a suitable potential function, and its parameters, which is then used to correlate theory with experimental data, given the kinetic theory expressions for the transport coefficients. The method has recently been expanded and generalized and the results of this general study are applied in this note. The potential functions examined were members of the m-6, Kihara, Exp: 6, and Morse families. It was found that the Kihara was most suitable for neon, and the m-6, with m=17 and m=24, was most suitable for krypton and xenon, respectively. Viscosity and thermal conductivities were calculated from these functions and tables are given between 100 and 1000 °K.

TN353. **Connector for saturated standard cells,** J. J. Barth, NBS Tech. Note 353 (April 21, 1967).

Key words: Connector; electromotive force; oil baths; standard cells; thermoelectric.

This paper describes a connector used for making electrical connections to saturated standard cells in oil baths. The connector has at least three advantages over other methods in common use. These advantages are namely: (1) it does not generate thermoelectromotive forces; (2) it allows cell racks to be placed close together in the bath; and (3) it is economical to fabricate since it can be made from a common inside caliper.

TN354. **The single-engine Claude cycle as a 4.2 °K refrigerator,** R. C. Muhlenhaupt and T. R. Strobridge, NBS Tech. Note 354 (June 1, 1967).

Key words: Claude; cryogenics; refrigeration.

The performance of the 4.2 °K Claude-cycle refrigerator has been computed taking into account the efficiencies of the various components. The results are presented in graphical form. These charts give the input power requirements, mass flow rates for both the compressor and expander, pertinent temperatures, and allow selection of the optimum high pressure for a given set of component characteristics.

TN355. **Correlations for predicting leakage through closed valves,** J. Hord, NBS Tech. Note 355 (Aug. 1, 1967).

Key words: Leak detection; leak flow rates; leak rates; leakage through valves; predicting leak rates; seal leakage; valve seat leakage.

Safety, convenience, and economy often demand the inference of leakage of a given fluid from known leakage of another test fluid across valve seats, welded and threaded fittings, seals, etc. The temperatures of the fluids also may be different. An example is the prediction of gaseous hydrogen leakage at 20 °K from test data obtained with nitrogen gas at 77 °K. Various flow formulae (molecular, transition, and continuum) are examined, and two simple methods of correlating leakage for single-phase fluids are deduced. The correlations obtained (excluding transition flow through long channels) indicate the leakage is inversely proportional to the square root of the density, or inversely proportional to the absolute viscosity, of the fluid. Thus, for gases, the leakage is directly proportional to the sonic velocity of the gas. The proper relationship must be established by experiment for each valve, fitting, etc.

TN356. **Comparison of incompressible flow and isothermal compressible flow formulae,** J. Hord, NBS Tech. Note 356 (Aug. 17, 1967).

Key words: Compressible flow; flow comparison; fluid flow; incompressible flow; mass flow; pressure drop.

Mass flow formulae for incompressible and "modified-incompressible" flow are compared with the isothermal compressible flow relation under the following conditions: The gas flow is steady, isothermal, and fully developed in a horizontal pipe of constant cross section with a prescribed static pressure drop (P_1-P_2). The comparative data are limited to static pressure ratios $(P_2/P_1) > \frac{1}{2}$, and subsonic isothermal flow. Laminar and turbulent flows are treated. Under the limitations of the comparison, modified-incompressible flow and isothermal gas flow relations are identical when $fL/2D \gg \ln(P_1/P_2)$. Graphical plots idicate the degree of approximation or error involved in using incompressible relations to solve compressible flow problems. Pressure losses due to end effects are briefly discussed.

TN357. **Signal design for time dissemination: some aspects,** J. L. Jespersen, NBS Tech. Note 357 (Nov. 2, 1967).

Key words: HF; noise; satellite; synchronization; time and frequency dissemination; VHF; VLF.

The purpose of this paper is to discuss, in a general way, some problems of time signal dissemination in a noisy environment. Most of the paper applies to any timing system, but particular emphasis is given to a CW two-frequency system. This is done for two reasons: first, as will be shown, a two-frequency CW system evolves naturally from fundamental considerations to meet certain user requirements; and second, a two-frequency VLF system is being investigated experimentally at the present time.

TN358. **A review of studies made on the decade fluctuations in the earth's rate of rotation,** W. R. Davey, NBS Tech. Note 358 (Oct. 16, 1967).

Key words: Core-mantle coupling; decade fluctuations; dynamo theory; earth's core; geomagnetism; rotation of the earth; westward drift.

Studies of variations in the length of the day (l.o.d.) on the order of a few milliseconds over the period of a few decades are briefly reviewed. In this connection, studies of the dynamo theory of geomagnetism, the westward drift of the magnetic field, and electromagnetic core-mantle coupling preface the theory of the decade fluctuations in the l.o.d.

TN360. **On the selection of the intermolecular potential function: Application of statistical mechanical theory to experiment,** H. J. M. Hanley and M. Klein, NBS Tech. Note 360 (Nov. 20, 1967).

Key words: Correlation; equilibrium properties; experimental data; intermolecular potential function; theory; transport properties.

We have developed a method here to evaluate quantitatively the relationship between model intermolecular potential functions and macroscopic experimental properties. Specifically, we have studied the function families: m-6, Kihara, exp:6, and Morse, and the properties: viscosity coefficient, diffusion coefficient, second virial, and Joule-Thomson coefficient. Our method is not restricted to these functions and properties; it is valid for any function and any property provided the appropriate theoretical expressions are available.

The principal conclusions from this work are: 1. A temperature range exists (around room temperature for most substances) in which data are completely insensitive to the potential function. This range makes is possible to quantitatively define what is meant by "high" or "low" temperatures. These definitions are most important when extrapolation of data arises. 2. The function families studied are essentially equivalent. 3. More than one function is required to represent data over a range of about 1000 °K. 4. We have estimated the experimental error which can be tolerated if experimental data are to be used to select a potential function. The conclusions are experimentally verified for both transport and equilibrium properties.

TN362. **Thermodynamic properties of He^3-He^4 solutions with applications to the He^3-He^4 dilution refrigerator,** R. Radebaugh, NBS Tech. Note 362 (Dec. 29, 1967).

Key words: Cryogenics; dilution refrigerator; enthalpy; entropy; Fermi-Dirac gas; helium-3; helium-4; liquid; mixtures; osmotic pressure; quantum fluid; specific heat; thermodynamic properties.

The thermodynamic properties of liquid He^3-He^4 solutions between 0 and 1.5 °K are calculated by using the weakly interacting Fermi-Dirac gas model for He^3 in He^4. Certain experimental data below about 0.4 °K are used to evaluate some of the parameters in the model. The properties of both He^3 in He^4 and the total solution are calculated for concentrations of He^3 up to 30 percent. All experimental data agree very well with the calculated results, although little data exist below 0.4 °K. The calculated properties are used to analyze the behavior of the He^3-He^4 dilution refrigerator in both the continuous and single-cycle processes. The maximum heat absorption below about 0.04 °K is found to be 82 T^2 joules per mole of He^3 circulated. The effect of an imperfect heat exchanger and He^4 circulation on the refrigeration capacity is discussed. An analysis of two new types of single-cycle processes is also given.

TN400. **Electrochemical analysis: Studies of acids, bases, and salts by Emf, conductance, optical, and kinetic methods, July 1965 to June 1966,** Edited by R. G. Bates, NBS Tech. Note 400 (Sept. 6, 1966).

Key words: Acidity; analytical chemistry; conductance; deuterium oxide; dissociation processes; electrochemistry; electrolytes; Emf; indicators; isopiestic; vapor pressure; methanol-water solvents; thermodynamics.

This survey of the activities of the Electrochemical Analysis Section, Analytical Chemistry Division, covers the period July 1965 to June 1966. An attempt is made to summarize a year's progress on the technical projects of the Section in such a way as to stress the program and capabilities of the organizational unit as a whole. A description of facilities and equipment is presented and the directions of new programs are indicated. Brief summaries of the several lines of work now under way are given. The main areas include the study of acidity measurement in water, deuterium oxide, and methanol-water solvents, along with the development and certification of standard reference materials with which acidity scales in these media can be defined. Solvent effects and isotope effects are being studied, and equilibrium data for certain systems of analytical interest have been obtained. Progress on a conductometric method for determining traces of water is reported, and the thermodynamic properties of some salt mixtures have been measured by a vapor pressure method. Kinetic methods for trace analysis have been examined, and a new lot of potassium hydrogen phthalate (Standard Reference Material 84h) has been certified for use as an acidimetric standard. The survey concludes with lists of the members of the Section staff, publications and manuscripts produced during the year, talks given by the staff, and committee assignments.

TN401. **Activities of the NBS Spectrochemical Analysis Section, July 1965 to June 1966,** Edited by B. F. Scribner, NBS Tech. Note 401 (Sept. 30, 1966).

Key words: Analysis; arc temperature; atomic absorption spectrometry; analog computer; bibliography; computer; electrodeposition; electron back scatter; electron probe microanalyzer; emission spectroscopy; laser probe; mass spectroscopy; photographic photometry; plasma jet; preconcentration; pulse height analyzer; spectrochemical analysis; spectroscopy; standard reference materials; time-shared computer; x-ray spectroscopy.

A summary is given of the activities of the NBS Spectrochemical Analysis Section for the period from July, 1965 through June, 1966, during which the move into the new facilities at Gaithersburg, Md. was made. Activities in optical spectrometry included development of programs for calculations on a time-sharing computer, measurement of arc temperatures, applications of the laser probe and the plasma jet, and studies on atomic absorption spectrometry. In x-ray spectroscopy, there have been some modifications of equipment, improvements in computation methods, and several applications. Improvements and additions were made to the electron probe analyzer, along with studies on measurement techniques, including non-dispersive analysis and computation procedures. The spark-source mass spectrometer has also been modified, and a new analog computer has been built and tested for reduction of photographic plate data; applications of this instrument to analyses of pure materials are described. Enrichment methods are being studied for the analysis of pure materials by emission spectroscopy, particularly with an electrodeposition technique. Homogeneity studies and analyses have been performed in the development of standard reference materials. Other activities included analyses of samples to assist other NBS groups and government agencies, and literature surveys. Listings are given of 20 publications and 26 talks by members of the Section during the year.

TN402. **Analytical coordination chemistry: Titrimetry, gravimetry, flame photometry, spectrophotometry, gas evaluation and isotopic preparations, July 1965 to June 1966,** Edited by O. Menis, NBS Tech. Note 402 (July 21, 1967).

Key words: Spectrophotometric titration; controlled potential coulometric; molybdenum; homogeneous precipitation; aluminum; beryllium; thermoanalytical standards; tricalcium silicate; spectrophotometry; antimony; high precision determination of nickel; simultaneous determination copper; cobalt; "releasing agents" in flame emission and atomic absorption; magnesium; ferrous SRMs; stoichiometric mixtures uranium oxide; isotope ratio determination.

Studies in four areas of analytical chemistry: titrimetry, gravimetry, flame emission and atomic absorption, and solution spectrophotometry, are described from the standpoint of analytical coordination chemistry and applications to NBS standard reference materials. In the first two competences these investigations dealt with spectrophotometric titrations and homogeneous precipitation methods. Advances are described in the latter two areas through the unique applications of ternary complexes, displacement reactions in metal-ligand systems and the use of complexing media as "releasing agents". This approach is described for the determination of nanogram quantities of Sb, Cu, Ni and Au in very high purity zinc by both spectrophotometric and flame procedures. Also in flame emission and atomic absorption a current table is presented for the detection limits of 70 elements. Progress of a new method is reported for the simultaneous determination of Ni, Cu and Co by the dimethylglyoxime method. Descriptive tables of results are also given for ferrous, non-ferrous and ceramic materials which were analyzed by one of the four competences. In another analytical area dealing with the analysis of gases in metals results of homogeneity and precision studies lead to certification of three new ferrous SRM's for their oxygen content. Also reported are the initial investigations of pyrohydrolytic separations of fluoride, nitrides and borons, separations of molybdenum from tungsten, controlled potential coulometric titration of molybdenum, and a description of improved instrumentation in flame emission and atomic absorption. Finally data are given on the preparation of stoichiometric mixtures of uranium oxide of varied isotopic composition and a list describing the variety of special analyses is included.

TN403. **Microchemical Analysis Section: Summary of activities, July 1965 to June 1966,** Edited by J. K. Taylor, NBS Tech. Note 403 (Sept. 1, 1966).

Key words: Atomic weights; coulometric analysis; gas analysis; mass spectrometric gas analysis; microchemical analysis; polarographic analysis; standard reference materials, analysis of; stoichiometry.

This report describes the scientific programs and research activities of the Microchemical Analysis Section of the Analytical Chemistry Division of the NBS Institute for Materials Research during the period July 1965 to June 1966. General activities are reported in the areas of gas analysis by mass spectrometry, polarography, coulometry, stoichiometry, and classical microchemical analysis. Research accomplishments described in some detail include: improvements in the sensitivity of gas analysis using high-pressure mass spectrometry; analysis of deuterated compounds by mass spectrometry; comparative polarographic analysis of high precision; polarographic methods for trace and ultra-trace determination of a number of elements; highly accurate coulometric iodimetric titration; a highly precise method for determination of magnesium based on its final weighing as magnesium sulfate; and a number of microchemical procedures for the analysis of a variety of materials.

TN404. **Radiochemical analysis: Activation analysis, instrumentation, radiation techniques, and radioisotope techniques, July 1965 to June 1966,** Edited by J. R. DeVoe, NBS Tech. Note 404 (Sept. 30, 1966).

Key words: NBS reactor; NBS Linac; Cockroft-Walton generator; digital computers; activation analysis; standard reference materials; photo-neutron reactions; flux monitors; Cu, Se, Al, V in irons and steels; homogeneity testing; pneumatic rabbit sensor; Mossbauer spectroscopy; tin standard for chemical shift; PARLORS program for Mössbauer spectra; Mössbauer instrumentation; Mössbauer laboratories; radiometric trace chromatography; radioisotope dilution; substoichiometry by controlled potential coulometry; radiochemical separations; theoretical detection limits for activation analysis; CLSQ program for multicomponent decay; solid state detectors; electronic data handling.

This is the third summary of progress of radiochemical analysis which encompasses the work of both the Radiochemical Analysis and Activation Analysis Sections of the Analytical Chemistry Division at the National Bureau of Standards.

Pertinent information on the irradiation facilities of the nuclear reactor, Linac, and Cockroft-Walton generator are described. A number of analyses of standard reference materials by activation analysis are described (e.g., Cu in cast iron, SRM 82b; Se in selenium steel, SRM 1170; Al in steel, SRM 14e; and V in stainless steel, SRM 73c). Various aspects of the technical problems in activation analysis such as its use for homogeneity testing, production of suitable flux monitors, and experimental design with respect to increasing selectivity (such as by using variable neutron energy) and reducing systematic and random errors, are presented. A realistic procedure for estimating sensitivity and for designing the analysis to optimize the detection limit is described. A computer program that resolves complex decay curves utilizes parameter changes convenient for the conversational aspect of "time sharing" digital computers. A highly specific radiochemical separation for copper using a type of amalgam exchange is described.

Description of specialized data handling equipment as well as information on a fast rise preamplifier, solid state detector system, and other special instruments such as a pneumatic transport system rabbit sensor, are presented.

A description of the laboratories used in Mossbauer spectroscopy is presented. Special problems in radiation detection for use in a spectrometer are also described. The Standard Reference Material Program for chemical shift in Mossbauer spectroscopy is discussed with particular reference to the search for a tin standard. The computer program, "Parlors M," that is used for resolving complex Mossbauer spectra is presented in its entirety in Appendix II.

The use of thin layer chromatography in conjunction with radioactive reagent analysis for trace elements is described. Substoichiometric radioisotope dilution continues to be studied by evaluating systematic and random errors, as well as by developing the technique from physio-chemical principles such as controlled potential coulometry.

TN405. **Organic Chemistry Section: Air pollution studies; kinetic behavior of sugars in solution carbon-14- and tritium-labeled carbohydrates; characterization of chemical structures; phenylhydrazono-phenylazo tautomerism; synthesis of research materials, cyclopentitols and related substances; novel research materials; standard reference materials (organic), July 1965 through June 1966,** Edited by H. S. Isbell, NBS Tech Note 405 (Sept. 30, 1966).

Key words: Air-pollution studies; oxidation of polycyclic aromatic hydrocarbons; sugars in solution; conformational analysis; carbon-14- and tritium-labeled carbohydrates; large-scale paper chromatography; phenylhydrazono-phenylazo tautomerism; cyclopentitols and related substances; unsaturated alditols; infrared spectra of acylamido derivatives; carbohydrate reference materials; metallo-organic standard reference materials.

This report describes work in progress in the Organic Chemistry Section of the Analytical Chemistry Division of the NBS Institute for Materials Research. It includes certain historical material, presented to give perspective to the overall program. The following research areas are discussed: air-pollution studies, kinetic behavior of sugars in solution, carbon-14- and tritium-labeled carbohydrates, characterization of chemical structure; phenylhydrazonophenylazo tautomerism, synthesis of research materials: Cyclopentitols and related substances, novel research materials, and standard reference materials.

TN406. **X-ray wavelength conversion tables and graphs for qualitative electron probe microanalysis,** K. F. J. Heinrich and M. A. M. Giles, NBS Tech. Note 406 (Sept. 25, 1967).

Key words: Electron probe microanalyzer; wavelengths; x-ray emission; x-ray spectrometers.

Tables and graphs have been constructed for electron probe x-ray spectrometers equipped with crystal changers and calibrated for LiF crystals in angstroms. These tables indicate the equivalent reading for the lines which can be normally expected to appear in wavelength scans using the following crystals: LiF, EDDT, ADP, KAP, and Pb stearate (LSD). The readings were extracted from the tables of E. W. White, et al. The tables are arranged by the atomic numbers of the emitting elements; the graphs show the readings for observable lines as a function of atomic number for each of the aforementioned crystals. A suggested method for using the tables and graphs is included.

TN408. **Superconductive materials and some of their properties,** B. W. Roberts, NBS Tech. Note 408 (Sept. 26, 1966).

Key words: Bibliography; compilation of data; composition; critical field; critical temperature; crystallographic data; low temperature; superconductivity.

This is a noncritical compilation of data on superconductive materials that has been extracted from the literature published between October 1963 and December 1965. The properties concerned are composition, critical temperature, critical field crystallographic data, and lowest temperature tested for superconductivity. The compilation also includes bibliography, general reference review articles and a special tabulation of high magnetic field superconductors.

TN409. **Fortran programs for the calculation of Wigner 3j, 6j, and 9j coefficients for angular momenta ≤ 80,** R. S. Caswell and L. C. Maximon, NBS Tech. Note 409 (Nov. 15, 1966).

Key words: Fortran program; Wigner coefficients; quantum theory of angular momentum; 3j coefficient; 6j coefficient; 9j coefficient; Clebsch-Gordan coefficients.

Fortran II and Fortran IV programs are given for the calculation of Wigner 3j, 6j and 9j coefficients containing individual angular momenta less than or equal to 80. The large numbers, resulting from the factorials which appear in the expressions for these coefficients, are handled by taking logarithms and performing most of the pertinent arithmetic with the logarithms. The alternating series involved in the expressions for the 3j and 6j coefficients are summed arithmetically in double precision. We present two versions of the basic program for the calculation of these coefficients (each version being given both in Fortran II and in Fortran IV). All programs are called as single-precision Fortran functions. The difference between Versions I and II is in the internal structure of these programs. In Version I, only the series summation is in double precision, resulting in a faster program which occupies less memory in the computer, the computation time being of the order of 0.001 to 0.01 sec per 6j and 0.1 to 1 sec per 9j. Version II, being entirely in double precision internally, is much more accurate (the errors being of the order of one percent of the errors in Version I), but the computation time for a given coefficient is approximately 50% greater than in Version I. Information relative to the accuracy and memory requirements of the two versions of the program is provided, and Fortran II and IV lists of the programs and calling instructions are given.

TN410. **Improved Fortran program for single particle energy levels and wave functions in nuclear structure calculations,** R. S. Caswell, NBS Tech. Note 410 (Sept. 30, 1966).

Key words: Eigenvalues; eigenfunctions; energy levels; wave functions; single particle shell model.

An improved program has been developed for numerical calculations of single particle energy levels and wave functions for Woods-Saxon or other real potential wells. The program is designed to be used as a subroutine of a larger program for nuclear structure calculation but may be used separately if desired. Improvements over the previous program include: (1) for bound states the wave function is calculated by integrating outward from zero radius and inward from a maximum radius beyond the nuclear potential well with matching at an intermediate radius; (2) a first order correction has been made to the starting conditions at small radius for the integration of the wave function; (3) a large step size is used until the calculation has nearly converged on the eigenvalue; then a small step size is used to provide maximum accuracy; (4) the correction of a small error in the Kutta-Runge integration procedure has been made. As a result of the changes the program is approximately five times faster than the previous version. Checks with harmonic oscillator potentials give an accuracy of .01% in the energy level values. Listings of Fortran II and Fortran IV versions are given.

TN411. **Methods for performance-testing of electro-mechanical pressure transducers,** P. S. Lederer, NBS Tech. Note 411 (Feb. 9, 1967).

Key words: Electro-mechanical; pressure; transducer; calibration; performance; test method; dynamic calibration and telemetering.

This publication describes methods in one particular program at NBS for the performance-testing of electro-mechanical pressure transducers (such as telemetering transducers used in aerospace testing). It covers static and dynamic calibration procedures in detail, delineates environmental and other tests, and describes the test equipment used. Examples of dynamic calibration results are interpreted.

TN412. **Quantum mechanical calculations of the second virial coefficients for hydrogen,** M. E. Boyd and S. Y. Larsen, NBS Tech. Note 412 (Apr. 10, 1967).

Key words: Second virial coefficient; quantum mechanics; hydrogen; equation of state; statistical mechanics; intermolecular potential.

Quantum mechanical second virial coefficients of dilute ortho and para hydrogen have been calculated for the case of a Lennard-Jones potential. These computations cover the temperature range from 0 °K to 80 °K. Special attention is paid to the behavior of the Boltzmann and exchange contributions. The purely statistical contribution to the ortho-para difference is shown to vanish to three decimal places by about 10.5 °K. Comparison with experimental data indicates that considerable improvement in the potential function and inclusion of non-spherical terms will be required at the low temperatures considered here.

TN413. **The solid system. II. Numeric compression,** P. A. D. deMaine, K. Kloss, and B. A. Marron; and **The solid system. III. Alphanumeric compression,** P. A. D. deMaine, B. A. Marron, and K. Kloss, NBS Tech. Note 413 (Aug. 15, 1967).

Part I.

Key words: Numeric compression; information handling; high-speed information transmission; information storage and retrieval; systems analysis.

This part of NBS Technical Note 413 describes the general NUMERIC COMPRESSOR (NUPAK) Algorithm for automatically compressing (encoding) or decoding compressed numerical information, which may of course have come from graphical information. The amount of compression achieved is determined by the "lowest limit of significance," the range, and the sequential patterns of the data to be stored. The encoded information can be stored in memory or on external storage devices in a small fraction of the space normally required, and can be expanded (decoded) item-by-item whenever needed by the system.

Part II.

Key words: Alphanumeric compression; information handling; high-speed information transmission; information storage and retrieval; systems analysis.

An algorithm for compressing alphanumeric information is described. Unlike other methods which depend upon frequency of occurrrence of words in a particular class of publications, this scheme is language and content independent since the information for compression is obtained from the text itself. The compressed bit stream is preceded by sufficient information for automatic reconstruction of the original bit stream whenever the system requires it. Even with this additional information required for expansion, compression rates approaching 40% have been achieved. Because this ALPHANUMERIC COMPRESSOR (ANPAK) is fully automatic and self-organizing, it can operate on information which has already been compressed via the NUMERIC COMPRESSOR (NUPAK).

TN414. **Quantitative methods for management,** G. Suzuki, NBS Tech. Note 414 (May 23, 1967).

Key words: Operations research; quantitative analysis; management; decision-making; education.

An elementary treatment of some of the better known and widely used analytical methods in operations research/systems analysis. The material is presented in a manner which attempts to indicate why quantitative methods are useful in managerial decision-making situations. Some basic references are provided.

TN415. **Thermal radiation property measurement techniques,** S. T. Dunn, J. C. Geist, D. G. Moore, H. E. Clark, and J. C. Richmond, NBS Tech. Note 415 (Apr. 27, 1967).

Key words: Averaging spheres; diffuse reflectance; emissivity; emittance; flux averaging devices; infrared reflectance; spectral reflectance; spectral emittance; specular reflectance.

This is an annual summary report of work completed on NASA Contract R-09-022-032. The work comprised (1) completion of the development and calibration of a rotating cylinder procedure for measuring normal spectral emittance of non-conducting materials at temperatures in the range of 1200 to 1600 °K, (2) analysis and calibration of an ellipsoidal mirror reflectometer, and (3) a study of the relation between surface roughness and geometric distribution of flux reflected from a surface.

TN416. **Study of a Halpern-type 4π neutron detector,** H. M. Gerstenberg and E. G. Fuller, NBS Tech. Note 416 (June 12, 1967).

Key words: Detector; efficiency; four-pi; Halpern; neutron; photoneutron; response; yields.

The response to various neutron spectra of a 2-inch diameter BF_3 proportional counter in a Halpern-type geometry has been studied as a function of moderator thickness. Neutron sources used were a calibrated RaDBe(α,n) source and a series of photoneutron sources using a number of bremsstrahlung spectra. The reactions used were $^{16}O(\gamma,n)$, $^{31}P(\gamma,n)$ and $d(\gamma,n)$. For these sources absolute neutron yields were determined either from the residual $\beta+$ activity or from the known cross section and the absolute bremsstrahlung intensity. Using these empirical data a final detector with 13 BF_3 counters was constructed. Over the spectral range covered by the above sources the measured efficiency for counting neutrons of the final detector was 9.6 percent with an estimated uncertainty of ±0.5 percent, independent of spectrum. The detector was used to measure the neutron yields from Pb, Au, Ta, Ho, Ag, Cu, Co, Ca, P, Al, O and C for a series of bremsstrahlung energies between 12.0 and 29.0 MeV. These yields were compared with those calculated from previously published neutron yield cross sections. The data indicate that previously reported discrepancies in neutron yield data can probably be traced to the determination of neutron detector efficiencies.

TN418. **Radiometric methods for measuring laser output,** D. A. McSparron, C. A. Douglas, and H. L. Badger, NBS Tech. Note 418 (Nov. 1967).

Key words: Laser; laser energy measurement; optical attenuator; photoelectric photometry; radiometric calibration; radiometry.

The output of pulsed lasers may be measured with reasonable accuracy by modifications of established radiometric methods. The receiver, thermopile or phototube, is used ballistically. It is calibrated by an incandescent-lamp standard of spectral irradiance. The laser beam is attenuated to make its irradiation on the receiver comparable to that from the calibrating source. Attenuation is accomplished by intercepting the entire laser beam on a diffusely reflecting surface. The attenuation factor is determined from direct measurement of the reflectance of this diffusing surface and the geometric constants of the system. The accuracy of the measurement of laser output is dependent upon the accuracy of calibration of the standard of spectral irradiance and the accuracy with which the spectral sensitivity of the receiver, the spectral transmittance of the band-pass filters, and the reflectance of the diffuser can be determined. Measurements made with different photoelectric receivers agree to about 1.5% using a 1/4-joule pulsed ruby laser as a source. Total uncertainty is estimated to be about 5%. Measurements made using these radiometric methods have been compared with calorimetric measurements and a discrepancy of 9% was observed.

TN420. **Drawings of micrometer U-tube manometers for the ranges up to 100 mm of mercury,** A. M. Thomas and J. L. Cross, NBS Tech. Note 420 (Aug. 26, 1967).

Key words: Manometer; micrometer; u-tube; vacuum; medium-vacuum measurements.

Drawings with sufficient detail are presented so that micrometer U-tube manometers for use with mercury, oil, and water may be constructed. Measurements made with the oil manometer have an uncertainty of about 4×10^{-4} mm of Hg plus one part in 10^4 of the reading. Measurements made with the mercury manometer have an uncertainty of about 4×10^{-3} mm of Hg plus eight parts in 10^5 of the reading. The operation and an error analysis are described elsewhere.

TN421. **Radiochemical analysis: Nuclear instrumentation, radiation techniques, nuclear chemistry, radioisotope techniques July 1966 through June 1967,** Edited by J. R. DeVoe, NBS Tech. Note 421 (Nov. 1967).

Key words: Computers; cross sections; detection limits for analysis; flux monitors; Mossbauer instrumentation; Mossbauer spectroscopy; NBS Linac; nickel-61; PARLORS program for Mossbauer spectra; photoneutron reaction; solid state detectors; standard reference materials; tin standard for chemical shift.

This is the fourth summary of progress of the Radiochemical Analysis Section of the Analytical Chemistry Division at the National Bureau of Standards.

The section's effort comprises four major areas: Mossbauer spectroscopy, nuclear chemistry, nuclear instrumentation, and the application of statistics in nuclear and analytical chemistry.

A new design of transducer which is more compact than the previous design has been made so that low temperature experiments can be more easily performed. A method of simultaneously measuring two spectra with a single transducer has been devised. A single line nickel-61 source has been made and the magnetic moment of the excited 5/2 state has been measured with this source. Efforts have continued on the interpretation of the spectral parameters and their relation to structure analysis. Studies are continuing on the production of a standard for chemical shift of tin compounds.

Equipment is in the final state of assembly and initial testing for measuring cross sections of reactions such as (γ,^{3}He) or (γ,^{4}He) by mass spectrometry of the reaction products.

The precision of an analytical method must be carefully used when expressing a detection limit. In addition, care must be taken to be definitive about the meaning of a limit of detection. A suggested procedure for uniformity in reporting these often used terms is presented in this report.

The practical operation of Ge(Li) and Si(Li) detectors has been evaluated. It is found that careful control of the preamplifier noise and response is required for optimum performance.

A study of the precision and accuracy of gamma-ray excited x-ray fluorescence was made. Using as a basis the analysis of certified Standard Reference Materials, an improvement of a factor of two in precision was measured. The major advantage concluded from this work is that if rapid analysis requiring portability is desired, the radioisotopic source approach is useful.

TN423. **Electrochemical Analysis Section: Summary of activities, July 1966 to June 1967,** Edited by R. G. Bates, NBS Tech. Note 423 (Oct. 1967).

> Key words: Acidity; analysis; conductance measurements; electrochemical analysis; electrochemistry of solutions; glass electrodes; medium effects; pH measurements.

This survey of the activities of the Electrochemical Analysis Section, Analytical Chemistry Division, covers the period July 1966 to June 1967. An attempt is made to summarize a year's progress on the technical projects of the Section in such a way as to stress the program and capabilities of the organizational unit as a whole. A description of facilities and equipment is presented, and the directions of the programs are indicated. Brief summaries of several lines of work now under way are given. The main areas include the measurement of acidity with progress toward the establishment of standards for pH, pH*, and pD being reported. Studies of the behavior of glass electrodes in deuterium oxide are described and solvent effects on ionic processes are discussed. Equilibrium data for certain ionic systems have been obtained, modifications of a precision conductance bridge are described, and a method for titrating hydrogen fluoride in dimethylformamide is outlined. The survey concludes with lists of the members of the Section staff, publications and manuscripts produced during the year, talks given by the staff, and committee assignments.

TN425. **Microchemical Analysis Section: Summary of activities, July 1966 to June 1967,** Edited by J. K. Taylor, NBS Tech Note 425 (Oct. 1967).

> Key words: Coulometric analysis; gas analysis; mass spectrometric gas analysis; microchemical analysis; null-point potentiometry; polarographic analysis; standard reference materials, analysis.

This report describes the research activities and scientific programs of the Microchemical Analysis Section of the Analytical Chemistry Division of the NBS Institute for Materials Research during the period July 1966 to June 1967. General activities are reported in the areas of gas analysis, polarography, potentiometry, coulometry, chemical microscopy, and classical microchemical analysis. Research accomplishments described in some detail include the following: high pressure mass spectrometry; high precision differential polarography; an improved coulometric technique for titration of halides; developments in micro null-point potentiometry; techniques for the accurate weighing of small liquid samples. A number of microchemical procedures which have been developed for the analysis of a variety of materials are also included.

TN426. **Analytical Mass Spectrometry Section: Summary of activities, July 1966 to June 1967,** Edited by W. R. Shields, NBS Tech. Note 426 (Sept. 15, 1967).

> Key words: Instrumentation; isotopic analyses; mass spectrometry; procedures.

This report describes the advances in instrumentation and the research activities of the Analytical Mass Spectrometry Section during the period July 1966 to June 1967.

Advances in instrumentation include the construction of a multi-stage mass spectrometer, a high vacuum beam valve, a Z focussing lens, a re-designed collector, a filament degas chamber, and new equipment for sample drying. The new facilities at Gaithersburg are described.

Elements studied during this period include: B, Cr, Pb, Rb, U, and Pu. Chemical procedures are given for B, Cr, Pb, and Pu; mass spectrometric procedures are given for B, Cr, Pb, Pu, Rb, and U.

TN427. **Organic Chemistry Section: Air pollution studies; characterization of chemical structures; synthesis of research materials; novel research materials; isotopic methods for analysis of carbohydrates; occurrence, preparation, and properties of naturally occurring monosaccharides (including 6-deoxy sugars); standard reference materials (organic), July 1966 through June 1967,** Edited by R. Schaffer, NBS Tech. Note 427 (Oct. 1967).

> Key words: Air pollution studies; characterization of chemical structures; disaccharide of d-lyxofuranose; infrared absorption methods for analysis of carbohydrates; naturally occurring monosaccharides and 6-deoxy sugars; oxidation of polycyclic aromatic hydrocarbons; phenylhydrazono-phenylazo tautomerism; quebrachitol, levo-inositol; standard reference materials; 1,2-0-isopropylidene-β-L-idofuranose; 2,3-0-isoptropylidene-β-d-threo-pentulofuranose.

This report describes work in progress in the Organic Chemistry Section of the Analytical Chemistry Division of the NBS Institute for Materials Research. The following research areas are discussed: air pollution studies; characterization of chemical structures; synthesis of research materials; a disaccharide of d-lyxofuranose; novel research materials; isotopic methods for analysis of carbohydrates; occurrence, preparation, and properties of naturally occurring monosaccharides, including 6-deoxy sugars; and standard reference materials.

TN428. **Activation analysis: Cockcroft-Walton generator, nuclear reactor, Linac, July 1966 through June 1967,** Edited by J. R. DeVoe, NBS Tech. Note 428 (Nov. 1967).

> Key words: Activation analysis; biological; botanical samples; carbon in sodium; Cockroft-Walton generator; digital computers; flux monitors; high precision 14 MeV neutron activation; homogeneity testing; instrumentation; NBS Linac; NBS reactor; photoneutron reactions; self absorption corrections; standard reference materials; vanadium in irons and steels.

This is the first separate (not combined with that of Radiochemical Analysis) summary of progress for the

Activation Analysis Section of the Analytical Chemistry Division of the National Bureau of Standards.

Pertinent information on the irradiation facilities of the nuclear reactor, Linac and Cockcroft-Walton generator are described. The initial installation of pneumatic transfer tubes is completed. Of great significance is the completion of a clean room that is used for pre-irradiation chemical separation for high sensitivity activation analysis.

A dual-sample biaxial rotating 14 MeV neutron-irradiation assembly has been tested. This assembly is part of a system that is controlled by a relay type of programmer to automate those irradiation steps that adversely affect precision of the analysis. This system was used to improve greatly the precision of analysis for oxygen and fluorine.

As a result of improved precision with the 14 MeV neutron irradiation, a study of systematic errors is now possible. Efforts to establish a reproducible correction factor for neutron and gamm-ray absorption between different matrices within the sample have shown considerable promise.

Standard Reference Material (SRM) steel chip Nos. 3b, 3c, and 30f have been analyzed for vanadium. Preliminary analyses of high purity platinum (a potential SRM) showed silver, copper, gold, palladium, and iridium at the ppm level. Future biological SRM's, (tree leaves, and beef liver) were tested for homogeneity and found satisfactory.

A variety of service analyses were performed. In particular, very pure aluminum was found to contain fractions of a ppm of chromium and scandium.

Additional efforts are being made to monitor reactor neutron fluxes. Additional nuclear instrumentation is being assembled to improve the versatility of the analysis technique.

Performance of the bremsstrahlung target, used with the linear electron accelerator, has been evaluated. Photon intensity distribution and stability was found to be within usable range. Analyses using the (γ,n) or (γ,p) reactions have been developed for magnesium in steels, and carbon in sodium metal.

TN430. **Designs for surveillance of the volt maintained by a small group of saturated standard cells,** W. G. Eicke and J. M. Cameron, NBS Tech. Note 430 (Oct. 9, 1967).

Key words: Control charts; experiment design; saturated standard cells; standard cells calibration; statistics; voltage standard.

This technical note describes a procedure for maintaining surveillance over a small group of saturated standard cells. The measurement process is briefly discussed and the principle of left-right balance as a means of eliminating certain systematic errors is developed. Specific designs and their analysis for intercomparing 3, 4, 5 and 6 cells in a single temperature controlled environment are given. Procedures for setting up control charts on the appropriate parameters are given, and a technique is described for detecting certain types of systematic errors.

TN431. **Second breakdown in semiconductor devices - A bibliography,** H. A. Schafft, NBS Tech. Note 431 (Oct. 1967).

Key words: Bibliography; device reliability; diodes; failure mechanisms; failure modes; second breakdown; semiconductor devices; thermal breakdown; transistors.

Almost 200 references with appropriate key words are listed which provide, it is believed, a comprehensive coverage of the literature of second breakdown in transistors and other semiconductor devices from 1958 through much of 1967. A representative list of earlier papers dealing with what appears to be second breakdown in point-contact and p-n junction diodes is also included. The indexes consist of an author index and an index to subject matter with reference tabulations and with key word assignments.

TN434. **"Life cycling" test on several strain gage pressure transducers,** P. S. Lederer, NBS Tech. Note 434 (Oct. 1967).

Key words: Life cycling; life testing; pressure cycling; pressure transducer; strain gage.

This publication reports the effects of many thousands of pressure cycles on the performance characteristics of several types of strain gage pressure transducers. The results obtained indicate permanent changes in zero pressure output and sensitivity. Most of these changes tend to occur during the first few thousands of cycles. The equipment and procedures used to obtain the data are described.

TN435. **The hyperbolic character of certain experimental results which tend toward limiting values,** A. F. Kirstein, NBS Tech. Note 435 (Nov. 1967).

Key words: Experimental; graphical solution; hyperbolic character; limiting values.

The hyperbolic character of certain experimental data obtained from structural and mechanical testing provides an extremely simple graphical method for use in approximating the limiting values associated with the data. The method, developed by Southwell to explain the behavior of eccentrically loaded thin elastic struts, is shown to have much wider application. A limited number of illustrations are given to describe the method and to show how it might be used as a research tool.

TN437. **Disclosures on: Autosort, an automatic collating and sorting machine; optical heterodyne refractometer; liquid metering pump; stable wideband relaxation oscillator using three inverting amplifiers; and seat belt webbing abrasion resistance testing machine,** Editors, D. Robbins and A. J. Englert, NBS Tech. Note 437 (Nov. 1967).

Key words: Abrasion resistance testing; automatic document distribution; flexible tubing pump; inverting amplifiers; laser beam phase shift; laser heterodyning; liquid metering pump; optical refractive index; programmed document distribution; relaxation oscillator; rotatable document bin array; seat belt webbing abrasion.

This Note presents descriptions and drawings of five devices that embody interesting and unusual solutions to problems frequently encountered in their respective fields. The devices are: autosort, an automatic collating and sorting machine, optical heterodyne refractometer, liquid metering pump, stable wideband relaxation oscillator using three inverting amplifiers, and seat belt webbing abrasion resistance testing machine.

Other disclosures on various subjects may be found in NBS Technical Notes 237, 253, 263, 282, 287, and 295.

TN438. **Compendium of *ab initio* calculations of molecular energies and properties,** M. Krauss, NBS Tech. Note 438 (Dec. 1967).

Key words: *Ab initio* electronic calculation; dipole moment; dissociation energy; electron affinity; energy; field gradient; magnetic constants; molecular electronic structure; orbital energy; polarizability; quadrupole moment; spectroscopic constants.

The number of *ab initio* molecular electronic calculations has increased dramatically in the last few years. Both the practitioners and other interested students of the results of the calculations have found it increasingly difficult to determine the present status of these calculations. This compendium references the work from 1960 to the present and abstracts from the mass of data the best values for several observable properties including the total energy, dissociation energy, electron affinity, spectroscopic constants, electric moments, field gradients, polarizabilities, and magnetic constants. In order to provide and insight into molecular electronic structure tables of orbital energies are also included.

These tables are meant to direct attention to the successes and failures of the calculations by compiling a large percentage of the best results in a reasonably compact form. Its usefulness will be limited in time by rapid advance in the field.

4. TITLES AND ABSTRACTS OF PAPERS PUBLISHED BY OTHERS, 1966-67

Reprints from the journals listed in this Section may often be obtained directly from the authors. See Section 5.2 on page 109 for additional information.

9150. **A comparison between a switched and a correlation radiometer for cryogenic noise source measurements,** D. F. Wait and C. L. Trembach, (*ISA 20th Annual Conference and Exhibit, Los Angeles, Calif., Oct. 4-7, 1965*), *ISA Preprint* **14.4**-3-65 (Oct. 1965).

Key words: Cryogenic noise source measurements; microwave; noise source measurements; radiometer.

A microwave sum-and-difference-correlation (S-D-C) radiometer is compared theoretically and experimentally with a microwave switching (Dicke) radiometer. Particular emphasis is given to the precision with which each radiometer can compare cryogenic noise sources.

9151. **A miniature helium turbo-expander for cryogenic refrigeration systems,** M. T. Norton, (*Proc. XI Intern. Congress Refrigeration, Munich, Germany, Aug. 1963*), Book, *Progress in Refrigeration Science and Technology* **I**, 131-135 (Pergamon Press Inc., New York, N. Y., 1965).

Key words: Design; expansion turbine; gas bearings; helium refrigeration; performance; 9800 RPS; 200 Watts (30 °K).

The Cryogenic Engineering Laboratory is investigating the use of small turbo-expanders, supported by gas bearings, which produce small amounts of refrigeration at 4.2 °K and 30 °K. The turbine and externally pressurized gas bearings used with the 4.2 °K system have previously been reported.

This paper describes a helium turbine expander designed for use in a closed cycle system. The turbine was designed to extract about 200 Watts at 30 °K from the helium flow. The turbine is 7.9 mm in diameter, rotates at 9800 revolutions per second, and was designed for an inlet pressure of 4 atmospheres and 4:1 pressure ratio. Tests covering pressure ratios from 4:1 to 6.4:1 indicate a peak efficiency at 65 percent. The turbine design philosophy and performance data of this turbine are given.

9152. **A precision pulse-operated electronic phase shifter and frequency translator,** J. A. Barnes and A. Wainwright, *Proc. IEEE* **53**, No. 12, 2143-2144 (Dec. 1965).

Key words: Frequency translator; phase shifter; universal time.

A reference signal is processed through a voltage variable delay line and a narrow band filter. After a voltage pulse of proper amplitude and shape is applied to the voltage variable delay line, the output signal from the narrow band filter has exactly one cycle of phase less (or more depending upon pulse shape) than the reference signal. By suitable processing, it is possible to generate precise submultiples of the one cycle (360 °) of phase and thus realize precise and stable phase shifts.

This system has great utility in the generation of small but precise frequency offsets such as are used in the generation of the coordinated universal time scales. To this end a rather compact unit has been constructed to offset the frequency of a 100 KHz signal from 0 to -500 parts in 10^{10} in steps of 50 parts in 10^{10}.

9153. **A survey of the thermodynamic data on heavier elements and their compounds: high-temperature enthalpy and vaporization equilibria,** T. B. Douglas, *Proc. 3d Meeting Interagency Chemical Rocket Propulsion Group, Working Group on Thermochemistry, El Segundo, Calif.*, Mar. 17-18, 1965, **I**, No. 82U, 5-16 (Chemical Propulsion Information Agency, Silver Spring, Md., July 1965).

Key words: Enthalpy; heavier elements; literature survey; refractory compounds; thermodynamic; vaporization.

A comprehensive, though not all-inclusive, survey of the published literature was undertaken for the purpose of determining where high-temperature enthalpy and vaporization-equilibrium data appear to be lacking or inadequate for Ti, Zr, W, Pb, Hg, I, Hf, Th, U, and their light-element compounds considered to be of possible importance in chemical propulsion and refractory applications. The results of this survey are summarized, and several examples are presented of the effects of uncertainties in the standard thermodynamic properties on calculated equilibria at high temperatures. It is pointed out that the first ionization potential of a molecule containing one alkali atom can be expected to exceed that of the free alkali atom by approximately the dissociation energy of the neutral molecule; and this relation is verified, within experimental uncertainty, for several examples.

9154. **Activation-analysis program and facilities at the National Bureau of Standards,** J. R. DeVoe and G. W. Smith, *Proc. 1965 Intern. Conf. Modern Trends in Activation Analysis, Texas A&M University, College Station, Texas*, pp. 225-229 (Apr. 1965).

Key words: Clean room; computers; counting rooms; feedback analysis; optimization of variables 10 MW nuclear reactor; pneumatic tubes; radiochemical laboratories; 14 MeV neutron generator; 100 MeV-40 KW LINAC.

The National Bureau of Standards' Radiochemical Analysis Section is now developing a capability in activation analysis to complement other analytical techniques using radioisotopes in analysis.

Activation analysis can be likened to spectrometric methods in which the re-emitted radiation from excited states (e.g. radioisotopes) which are often long (e.g. milliseconds to years) are measured and related to the kind and amount of element which interacted with the primary radiation. The analyst learns to discriminate from unwanted excitation processes by varying the type and energy of incident radiation, the length of time of the excitation, and the type of detector that measures the re-emitted or secondary radiation.

To be most effective for our applications of activation analysis a computer is best used in a regenerative feed-back loop which consists of selecting, in sequence; the proper nuclear reaction, time of irradiation, complexity of radiochemical separation, appropriate detector, stripping of time dependent radiation spectra, and judgment of the analyst. It should be emphasized that a selective combination of the above variables does not place too large a burden on any one of the variables. Plans for the development of facilities to carry out these concepts are discussed.

9155. **Additional observations on the electronic spectrum of copper (II) acetate monohydrate,** C. W. Reimann, G. F. Kokoszka, and G. Gordon, *J. Inorg. Chem.* **4**, No. 7, 1082-1084 (July 1965).

Key words: Bi-nuclear complex; copper (II) acetate monohydrate; polarized electronic absorption spectrum; tentative assignment based on selection rules.

The polarization properties of a previously undiscovered band in single crystals of copper (II) acetate monohydrate are reported. The absorption spectrum of copper (II) acetate monohydrate in the region 8000 cm^{-1} to 30,000 cm^{-1} is considered in terms of the requirements of the C_{4v}, C_{2v}, and C_2 symmetry groups.

9156. **Anniversaries in 1965 of interest to statisticians,** C. Eisenhart, *Am. Stat.* **19,** No. 5, 21-29 (Dec. 1965).

Key words: Anniversaries; history; probability; statistics; Pierre de Fermat; Gregor Mendel; Isaac Todhunter.

Patterned on the annual articles in the American Journal of Physics on "Anniversaries . . . of Interest to Physicists", this invited paper aims to initiate a similar series of articles in the American Statistician on "Anniversaries . . . of Interest to Statisticians".

The year 1965 marks the tercentennial of the death of Pierre de Fermat, co-founder, with Blaise Pascal, of the mathematical theory of probability; the centennial of the publication of Isaac Todhunter's *History of the Mathematical Theory of Probability* . . .; and the centennial of Gregor Mendel's oral presentation of the statistical laws of inheritance that today bear his name to the Brunn society for the Study of Natural Science. The lives and principal accomplishments of Fermat, Todhunter, and Mendel are reviewed from the viewpoint of their contributions to, and influence on, statistical theory and practice.

9157. **Applications of sulfur coating to integrating spheres,** S. T. Dunn, *Appl. Opt.* **4,** 877 (July 1965).

Key words: Coatings; infrared integrating sphere coatings; integrating spheres; sphere; sulfur coatings.

This letter describes several methods of preparing infrared integrating sphere coatings.

9158. **Atmospheric research and electromagnetic telecommunication,** H. G. Booker and C. G. Little, Part I, *IEEE Spectrum* **2,** No. 8, 44-52 (Aug. 1965); Part II, *IEEE Spectrum* **2,** No. 9, 98-103 (Sept. 1965).

Key words: Atmospheric research; electromagnetic; telecommunication; United States.

Part I--The broad subject of electromagnetic telecommunication in the United States is examined, with the stress on the importance of atmospheric research to this growing field.

Part II--The concluding portion of this two-part article presents an analysis of telecommunication-oriented atmospheric research in the United States for the fiscal year 1964.

9159. Unassigned.

9160. **Bond with reinforcing steel,** D. Watstein, *Am. Soc. Testing Mater. Spec. Tech. Publ.* **169A,** *Significance of Tests of Concrete Making Materials*, pp. 239-245 (July 1965).

Key words: Bond in pullouts and beams; bond strength; deformed reinforcement; review of bond literature.

A review is presented of the significance of various tests of bond between reinforcing steel and concrete. The effect of the more important parameters such as bar diameter, strength of concrete, and spacing of bars as determined in some recent researches is appraised, and the appropriate provisions of the standards for reinforced concrete construction are discussed. A brief discussion of the significance of bond and bond tests for prestressed concrete is also included.

9161. Unassigned.

9162. **Color,** D. B. Judd, *Encyclopedia of Physics*, pp. 113-116 (Reinhold Publ. Corp., New York, N. Y., 1965).

Key words: Chromatic adaptation; color; colorblindness; colorimetry; theories of color.

This three-page article gives the conditions for a color match by observers having normal vision and those having one or another of the six most common forms of abnormal vision. It gives the mathematical basis for color measurement, both visual and photoelectric, for automatic production of pictures in color, and for prediction of the influence of chromatic adaptation on color perception, and it indicates the chief property of four of the most respected theories of color.

9163. **Comments on the mechanism of the 337-micron CN laser,** H. P. Broida, K. M. Evenson, and T. T. Kiluchi, *J. Appl. Phys.* **36,** No. 10, 3355 (Oct. 1965).

Key words: Laser; radiation; rotational level; vibrational state; 337-micron CN laser.

Very intense laser radiation at 337 μ has been observed by Gebbie et al., when a pulsed electrical discharge is passed through various organic compounds such as HCN, CH_3CN and C_2H_5CN. Chantry et al., suggest a laser transition in the vibrational state $v=2$ of the ground electronic state $X^2\Sigma$ of CN from the rotational level $K=8$ to $K=7$.

If the proposed explanation is correct, then a number of other transitions should occur, some with considerably higher probability than the observed emission.

9164. **Congruence subgroups of positive genus of the modular group,** M. Newman and M. Knopp, *Illinois J. Math.* **9,** No. 4, 577-583 (Nov. 1965).

Key words: Congruence groups; genus; modular group.

Let $\Gamma(n)$ be the principal congruence subgroup of Γ of level n, Γ_n the subgroup of Γ generated by $\Gamma_{(n)}$ and $S=\begin{pmatrix} 1 & 1 \\ 0 & 1 \end{pmatrix}$, and $\Gamma_0(n)$ the subgroup of Γ consisting of all elements $\begin{pmatrix} a & b \\ c & d \end{pmatrix}$ of Γ such that $c \equiv 0 \pmod{n}$. Then it is proved that if G is a subgroup of Γ containing Γ_n, then either $G=\Gamma$ or $G \subset \Gamma_0(d)$, $d|n$, $d>1$. This is used to prove that a free congruence subgroup of Γ of level n (i.e., a free subgroup of Γ containing $\Gamma(n)$) is of positive genus, provided that $(n, 2.3.5.7.13)=1$.

9165. Unassigned.

9166. **Decays of positive-parity baryon resonances in a broken U(12),** H. Harari, D. Horn, M. Kugler, H. J. Lipkin, and S. Meshkov, *Phys. Rev.* **140,** No. 4B, B1003 (Nov. 1965).

Key words: Baryon; branching ratio; decay; decay width; meson; resonances; spurious; symmetry breaking; U(12) theory.

The positive parity baryonic resonances are classified and their decay widths calculated in a broken U(12).

9167. **Density and specific gravity,** J. K. Taylor, *Encyclopedia of Industrial Analysis* **1,** 546-560 (Interscience Publ. Inc., New York, N.Y., 1965).

Key words: Gravity; specific density.

Density is an important and significant property of matter. For pure materials, density values may serve as one means of identification. For binary mixtures, such measurements frequently provide convenient methods for analytical determination of composition. Density values also may be combined with other physical properties such as viscosity or refractive index for analytical or structural determinations. In solid-state chemistry, precise density data on pure materials may provide information of the number of dislocations present in a given specimen.

An extensive literature exists both on methods for measurement of density and on tabulations of measured values for a wide variety of materials. An exhaustive review of this literature is outside the scope of this chapter. In fact, the reader is urged to consult original sources, especially for details of precision methods. Instead, general considerations will be presented here, especially those that might be useful to the practicing analytical chemist.

9168. **Determination of trace amounts of cadmium and silver by substoichiometric radioisotopic dilution analysis,** A. R. Landgrebe, L. T. McClendon, and J. R. DeVoe, *Trans. Am. Nucl. Soc.* **8,** No. 2, 315-316 (1965).

Key words: Cadmium; dithizone; silver; sub-stoichiometric radioisotopic dilution analysis; trace amounts.

A new method, using a substoichiometric amount of the complexing reagent dithizone in radioisotope dilution analysis, was developed for the determination of trace amounts of silver and cadmium. Silver was determined in an acidic solution at pH 4.75, using a low concentration of dithizone, 10^{-8} g/ml. Cadmium was determined using ammonia-ammonium chloride buffer at the μg/ml level. The sensitivity of the method is limited by 1) there is a limit to which the organic reagent can be diluted and still retain the effect of substoichiometry, 2) the specific activity of the radioisotope, 3) impurities at low concentration, that may act with the substoichiometric reagent, 4) hydrolysis of the complexing reagent and analyzed elements, and 5) adsorption on glassware.

Two major advantages of the direct substoichiometric radioisotopic dilution analysis are 1) it is possible to determine a number of elements in the same sample by using agents, varying the pH, etc., 2) after adding the radioisotope to the solution being analyzed losses of the element being determined do not influence the results of the analysis.

9169. **Determination of trace amounts of tellurium in standard reference materials by neutron-activation analysis,** D. A. Becker and G. W. Smith, *Proc. 1965 Intern. Conf. Modern Trends in Activation Analysis, Texas A&M University, College Station, Texas,* pp. 230-235 (Apr. 1965).

Key words: Chemical separation; distillation; neutron-activation; tellurium.

For the first time, neutron activation was used for elemental analysis of NBS Standard Reference Materials at the National Bureau of Standards. The reference materials were of two general types, cartridge brass and white cast iron, and were analyzed for their tellurium content. Utilizing the nuclear reaction Te^{130} $(n,\gamma)Te^{131}$ β^- I^{131}, the samples were irradiated and the I^{131} separated by $\vec{a}$ destructive distillation and solvent extraction technique. Chemical yields were obtained through the use of I^{125} tracer. Tellurium concentrations of 2 to 800 ppm were determined, and the results compared to the results on identical samples obtained by polarography and emission spectroscopy.

9170. **Dissociation constant of acetic acid in deuterium oxide from 5 to 50 °. Reference points for a pD scale,** R. Gary, R. G. Bates, and R. A. Robinson, *J. Phys. Chem.* **69,** No. 8, 2750-2753 (1965).

Key words: Acetic acid; acidity in deuterium oxide; deuterium oxide; dissociation constant; heavy water; pD scale.

Electromotive force measurements of a cell without liquid junction have been used to determine the dissociation constant of acetic acid in deuterium oxide from 5 to 50 °. The enthalpy, entropy, and heat capacity changes on dissociation of acetic acid have been calculated. Values of - log $(a_{D+}\ \gamma_{Cl-})$ and the conventional pa_D values for the equimolal (0.05 m) acetic acid-sodium acetate buffer solutions have been determined. These provide a second fixed point for standardizing the pD scale, supplementing the equimolal mixture of KD_2PO_4 and Na_2DPO_4 established in an earlier investigation.

9171. **Dissociation of H_2^+ by electron impact,** G. H. Dunn, B. Van Zyl, and R. N. Zare, *Phys. Rev. Letters* **15,** No. 15, 610 (Oct. 11, 1965).

Key words: Dissociation; H_2^+; electron.

The cross section for dissociation of H_2^+ by electron impact has been measured over the electron energy range 25 eV^2 to 600 eV. Results are found to agree well with available theory when the Franck-Condon factors are assumed to describe the vibrational state population of H_2^+.

9172. **Effects of thermal shrinkage on built-up roofing,** W. C. Cullen, *J. Bldg. Res. Instr.* **2,** No. 4, 23 (July-Aug. 1965).

Key words: Deterioration; insulation; radiative cooling; roofing, built-up.

The effects of thermal movement of bituminous built-up roof membranes are related to some common failures of built-up roofing observed in field exposures. A procedure for determining the amount of thermal movement of built-up membranes is described. Data are given for the thermal movement of various bitumens and reinforcing felts used in the construction of built-up roofs and for the composite membranes over a temperature range of +30 to -30 °F. The data obtained are related to field experiences and suggestions are presented which will prove beneficial in reducing the incidence of built-up failure due to thermal movement.

9173. **Elastic constants of single crystal UO_2 at 25 °C,** J. B. Wachtman, Jr., M. L. Wheat, H. J. Anderson, and J. L. Bates, *J. Nucl. Mater.* **16,** 39-41 (1965).

Key words: Compressibility; elastic constants; elastic compliances; single crystal; velocity of sound; uranium dioxide.

The elastic constants of single crystal UO_2 at 25 °C were determined to be $c_{11}=3.95 \pm (0.018)$, $c_{12}=1.21 \pm (0.019)$, and $c_{44}=0.641 \pm (0.0017)$ in units of $10^{12}d/cm^2$. The numbers in parentheses are computed standard errors of the corresponding constants based on about 16 measurements of each transit time equired in four independent determinations of the set of three elastic constants.

9174. **Electrical testing in chemical technology,** A. H. Scott, *Encyclopedia of Chemical Technology,* 2d ed., **7,** 716-726 (1965).

Key words: Electrical testing; conductance; dielectric conductance; conductivity; volume conductivity; insulation conductance; resistance; dielectric resistance; resistivity; dielectric constant; permittivity; dissipation factor; loss index; dielectric strength; arc resistance; tracking; measurements.

Electrical testing of one sort or another is being used today to (a) determine the electrical properties of materials for design purposes, (b) determine the purity of the materials, (c) check the uniformity of manufacture or the maunfacturing process, (d) aid in developing an understanding of the molecular structure of materials, (e) characterize materials, and (f) indicate the influence of environment on the properties of materials. The purpose of this article is to briefly describe such electrical measurements and to indicate their usefulness and limitations.

9175. **Electron spin resonance studies of the reaction of water-soluble polymers with hydroxyl radicals,** F. Sicilio, M. Dousset, R. E. Florin, and L. A. Wall, (*Proc. 150th American Chemical Society Meeting, Atlantic City, N.J., Sept. 12-17, 1965*), *Polymer Preprint* **6,** No. 2, 958-964 (Sept. 1965).

Key words: Free radicals; polyvinyl alcohol; polyethylene oxide; tetrahydrofuran; hydroxyl radicals; electron spin resonance.

Free radicals were generated from polyvinyl alcohol, ethylene glycol, polyethylene oxide, dimethyl ether, tetrahydrofuran and dioxane, by the action of hydroxyl radicals from $TiCl_3 + H_2O_2$ on the substrates in an aqueous flow system, and were observed by electron spin resonance. The radical $\cdot CH_2OCH_3$ from dimethyl ether had a concentration of 7.9×10^{-7} M .02 sec after mixing at 2 to 7 °C, and a rate constant for disappearance of 0.4×10^8 liter/mole sec which is considerably greater than that for hydroxyl. The radical from polyvinyl alcohol is explainable either by abstraction from the CH_2 group, or by scission following abstraction from CHOH or CH_2. Tetrahydrofuran gives a very complicated spectrum attributed to the two cyclic radicals formed by abstraction in the 1 and 2 positions. The radical from polyethylene oxide appears to have four precisely equivalent protons with a splitting of 9.2 gauss, plus minor splittings, and is attributed to a positive ion radical, $\sim CH^{+\cdot}{}_2OCH_2\sim$ or $\sim OCH^{+\cdot}{}_2\text{-}CH_2O\sim$.

9176. **Fire test methods for paints,** A. F. Robertson, *Bldg. Res.*, pp. 48-52 (July-Aug. 1965).

Key words: Combustibility; endurance; fire; flammability tests; paints.

A discussion is presented of the applicability of various fire test methods to the evaluation of paint coatings from the fire safety viewpoint. Sixteen flammability test methods are briefly described and a limited amount of data are presented to show the type of correlation which exists between six of the test methods. It is emphasized that few, if any, of the paints currently available provide any but the most minor influence in delaying fire penetration through structures as measured by the fire endurance test ASTM Procedure E-119. Manufacturers are encouraged to attempt development of paints which show better performance by this method.

9177. **Floor coverings,** T. H. Boone, *Building Construction Handbook*, 2d Edition, Ed. F. S. Merritt, Section 13, pp. 13-1--13-8 (McGraw-Hill Book Co., Inc., New York, N. Y., 1965).

Key words: Adhesive industrial; characteristics; conductive; flooring; installation; standards.

Since every floor is a system comprising many parts, complete satisfaction with a flooring installation is experienced only when all parts perform well. Dissatisfaction can arise from failure to take into consideration during the earliest stages of building design the importance of each part, the type of environment, and traffic conditions to be encountered in the finished building.

This section summarizes the characteristics of nontextile floor coverings with the intent to be helpful in the selection of floor covering, adhesive, and in the preparation of the subfloor. Methods for properly installing these materials are described. Specifications, standards and floor trade associations are also listed.

9178. **Formation of crystallites of benzophenone in hydrocarbon glass,** R. Keller and D. Breen, *J. Chem. Phys.* **43,** No. 7, 2562-2563 (Oct. 1965).

Key words: Crystals; phosphorescence; triplet states.

Small, invisible crystallites of benzophenone are formed in dry hydrocarbon glass at 77 °K when the concentration exceeds 10^{-3} molar. The emission from these suspended crystallites is greatly reduced because of annihilation interactions between triplet excitons. The decay of phosphorescence of concentrated solutions following flash excitation was shown to result from a sum of the decay of phosphorescence of dissolved molecules plus the phosphorescent decay of benzophenone crystals. Additions of butyl alcohol to the dry hydrocarbon glass prevents the formation of these crystallites.

9179. Unassigned.

9180. **Gas-phase radiolysis and photolysis of neopentane,** S. G. Lias and P. Ausloos, *J. Chem. Phys.* **43,** No. 8, 2748-2759 (Oct. 1965).

Key words: Free radicals; ion-molecules reactions; neopentane; photolysis; radiolysis.

The photolysis of neo-C_5H_{12}-neo-C_5D_{12} mixtures has been investigated at 1470 and 1236A. From the products formed in the absence and presence of NO or H_2S, the occurrence of the following fragmentation processes could be derived:

$$\text{neo-}C_5H_{12}^{*} \rightarrow CH_4 + \text{iso-}C_4H_8 \qquad (1)$$
$$CH_3 + \text{iso-}C_4H_8 \qquad (2)$$
$$CH_3 + CH_3 + C_3H_6 \qquad (3)$$

These modes of decomposition also prevail when neopentane is excited by collision with electrons accelerated by an electrical field applied during radiolysis. At 1236Å, the relative probabilities of occurrence of processes 1, 2, and 3 are approximately 1.0, 4.5, and 1.1.

From the isotopic analysis of the products formed in the direct and inert gas sensitized radiolysis of neo-C_5H_{12}-neo-C_5B_{12} mixtures in the presence of NO, O_2 or I_2 as free radical scavengers, it could be derived that the fragment ions $C_2H^+{}_3$, $C_2H^+{}_5$, $C_3H^+{}_5$, and $C_3H^+{}_7$ are formed.

9181. **Geomagnetic and solar data,** J. V. Lincoln, *J. Geophys. Res.* **70,** No. 13, 3227-3228 (July 1965); **70,** No. 15, 3761-3763 (Aug. 1965); **70,** No. 17, 4383-4384 (Sept. 1965); and **70,** No. 19, 4963-4964 (Oct. 1965).

Key words: Data, geomagnetic and solar; geomagnetic solar data; solar data, geomagnetic.

9182. **Growth of large sodium chloride crystals from solution for color-center studies,** P. M. Gruzensky, *J. Chem. Phys.* **43,** No. 11, 3807-3810 (Dec. 1, 1965).

Key words: Alkali halides; aqueous; chloride; color centers; conductivity; crystal growth; sodium.

Sodium chloride single crystals with edge dimensions as large as 2.5 cm were grown from aqueous solutions. Solutions were purified by chemical precipitation of trace contaminants and filtration through membrane filters. Crystal defects were apparent in the initial stages of growth, but the outer portions of crystals were free of dislocations. F-band coloration by x-rays at room temperature was not linear and the "first stage" was either absent or nearly so. Transition from extrinsic to intrinsic dc conductivity occurred at 350 °C with the extrinsic conductivity two orders of magnitude lower than for "pure" melt-grown crystals.

9183. **High-resolution infrared spectra of cyanogen and cyanogen** $^{15}N_2$, A. G. Maki, *J. Chem. Phys.* **43,** No. 9, 3193-3199 (Nov. 1965).

Key words: Bond distances; cyanogen; infrared; molecular structure; spectra.

The infrared absorption of $^{12}C_2{}^{14}N_2$ and $^{12}C_2{}^{15}N_2$ has been studied with a resolution of 0.08 to 0.04 cm^{-1}. The vibration-rotation band constants were determined for eight vibrational transitions of $^{12}C_2{}^{14}N_2$ and three vibrational transitions of $^{12}C_2{}^{15}N_2$. Many unresolved hot band Q-branches were also measured. The values for many vibrational and rotational constants are given. The bond distances determined from the rotational analysis and their three-standard-deviation error limits, are r_0 (C-C)=$1.38_9 \pm 0.030$Å and r_0 (C≡N)=$1.15_4 \pm 0.017$ Å. The N-N distance and corresponding error limits are $3.69_7 \pm 0.010$Å.

9184. **Human engineering in the design of a console for the comparison of volt boxes,** P. H. Lowrie, Jr., *ISA J.*, pp. 67-71 (July 1965).

Key words: Calibration console; console; high measurement accuracies; human engineering; volt boxes.

Too often the human element is not given adequate consideration in the design of precise measuring equipment. The dependence upon the operator for the attainment of high measurement accuracies cannot be denied. This paper describes a calibration console in which the human engineering factors were given the same consideration as the technical requirements. In this system the operator is considered to be a decision maker, and those functions not requiring judgment are handled automatically by the console. Most of the calculations are performed automatically by internal circuits, and the results are displayed digitally upon command. The console is an illustration in point that the principles of human engineering are as applicable to the precise measurements found in the standards aboratory as they are to the production line. The paper discusses the features of the console and points out some of the pitfalls that may be encountered in a design of this type.

9185. Unassigned.

9186. **Infrasonic waves from aurorae,** K. Maeda and J. M. Young, *Nature* **207,** No. 4994, 279-281 (July 1965).

Key words: Atmospheric resonances; auroral infrasound; infrasonic waves; thermal structure.

The effects of atmospheric thermal structure on the free-field propagation of auroral infrasound are discussed. Experimental data illustrating dispersion and near-sinusoidal oscillations near the Brunt frequency are shown. The effects of the large positive lapse rate layers, especially the one in the thermosphere, on atmospheric resonances are given particular attention.

9187. Unassigned.

9188. **International intercomparison of standards for microwave power measurement,** G. F. Engen, *IEEE Trans. Microwave Theory Tech.* **MTT-13,** No. 5, 713-715 (Sept. 1965).

Key words: International intercomparison; microwave; microwave power measurement.

In compliance with a recommendation of the International Scientific Radio Union (URSI) intercomparisons of microwave power standards have been made between Japan, the United Kingdom, and the United States.

Initially, there was a rather large difference in the Japan/United States comparisons; but, after several improvements in the design of the bolometer mounts employed as a transfer standard, consistently good agreement of the order of a few tenths of a percent has been realized.

In intercomparisons between the United Kingdom and either Japan or the United States, there was a small but rather consistent difference in the initial results. Again, the agreement has improved with more recent comparisons.

The microcalorimetric and impedance methods were employed by Japan and by the United States to evaluate the bolometer mount efficiency, whereas in the United Kingdom a combination of calorimetric, force-operated, and bolometric methods were used. The close agreement achieved is thus particularly significant because of the wide differences in the basic principles of the techniques employed.

As a result of this program, the accuracy limits of the different methods may now be stated with greater confidence. In addition, the interchange of ideas has yielded improved instrumentation.

9189. **International URSIGRAM and world days service "report on activities 1964",** A. H. Shapley, *URSI Info. Bull.* **150,** 43-55 (May 1965).

Key words: Radio science; world days service.

9190. **Interspecimen comparison of the refractive index of fused silica,** I. H. Malitson, *J. Opt. Soc. Am.* **55,** No. 10, 1205 (Oct. 1965).

Key words: Dispersion; fused silica; infrared materials; optical materials; refractive index.

The index of refraction of optical quality fused silica (SiO_2) was determined for 60 wavelengths from 0.21 to 3.71 microns at 20 °C. The dispersion equation

$$n^2 - 1 = \frac{0.6961663\lambda^2}{\lambda^2 - (0.0684043)^2} + \frac{0.4079426\lambda^2}{\lambda^2 - (0.1162414)^2} + \frac{0.8974794\lambda^2}{\lambda^2 - (9.896161)^2}$$

where λ is expressed in microns was found to yield an absolute residual of 10.5×10^{-6}. The variation in index between 12 specimens was determined. Dispersive properties of the material and thermal coefficient of index are graphically presented. A comparison with previous NBS index data is discussed.

9191. **Intrinsic and lattice-induced distortion of the tetrachlorocuprate ion,** M. Sharnoff and C. W. Reimann, *J. Chem. Phys.* **43,** No. 9, 2993-2996 (Nov. 1965).

Key words: Copper doped tetrachlorozincate; e.p.r. analysis; Jahn-Teller effect; polarized ultraviolet spectrum; tetrachlorocuprate ion.

In an effort to determine how much of the distortion of the tetrahedral complex, $CuCl_4^=$, may be ascribed to the Jahn-Teller effect, we have studied the changes in the optical and EPR spectra which occur when this ion is embedded in several different lattices. Although the corresponding lattice constants of the isostructural crystals, Cs_2CuCl_4 and Cs_2ZnCl_4, differ by only about 3%, gross differences exist between the g-tensors of $CuCl_4^=$ suspended in these lattices. These findings are corroborated by a comparison of the optical spectra of the two complexes. The effects are discussed in terms of an LCAO-MO analysis of the primarily 3d(Cu) wave functions of the complex, and it is shown that the change in ionic distortion is connected almost exclusively with a small but significant change in the amount of 4p(Cu) character in the t_2 primarily 3d(Cu) orbitals. The analysis points towards the conclusion that the low symmetry (point group C_s) of the ion is an intrinsic property and that the dominant mechanism of the distortion of the ionic symmetry from T_d is the Jahn-Teller effect.

9192. **Investigation of polymer pyrolysis with thermogravimetry,** J. H. Flynn and L. A. Wall, (*Proc. 150th American Chemical Society Meeting, Atlantic City, N.J., Sept. 12-17, 1965), Polymer Preprint* **6,** No. 2, 945-955 (Sept. 1965).

Key words: Calculation of kinetic parameters; determination of activation energies; preexponential factor; stability of polymers; thermogravimetric analysis; variation of the activation energy.

A detailed theoretical analysis of thermogravimetry as applied to polymer decomposition investigations, particularly in regard to elucidating kinetic and mechanistic details, has been made and pertinent mathematical relations presented. Cases considered are realistic ones based on isothermal pyrolytic studies and include: 1) where the rate is dependent upon the conversion raised to a simple power, 2) where the rate proceeds through a maximum with conversion and 3) composite situations.

The changes in the shape of the thermogravimetric curves resulting from the variation of the activation energy, preexponential factor, and heating rate for the various cases are compared and discussed. The effect of a linear temperature dependence in the preexponential factor on the character of the curves is also examined.

From these general considerations, it appears that, although thermogravimetric analysis may be sufficient for the approximate determination of activation energies and overall relative stability of polymers, in most cases, complementary isothermal studies are necessary for the unambiguous interpretation of the kinetics and the calculation of kinetic parameters.

9193. **Ionospheric effects of particles,** G. C. Reid, *Proc. COSPAR Polar Cap Panel Symp., Alpach, Austria, 1964*, pp. 221-231 (Academic Press Inc., New York, N. Y., 1965).

Key words: Auroral absorption; auroral radar; ionospheric disturbances; polar cap absorption; solar protons; sporadic-E.

This paper is a summary of a review paper presented at the COSPAR Polar-Cap Panel Symposium. Current knowledge concerning energetic-particle effects in the ionosphere is briefly discussed, and outstanding problems are emphasized.

9194. **Ion-pair process in CH_3Cl photoionization,** V. H. Dibeler and J. A. Walker, *J. Chem. Phys.*, **43**, No. 5, 1842-1843 (Sept. 1965).

Key words: Ionization energy; ion pair process; photoionization.

A brief report on the first direct observation of both positive and negative members of an ion pair process by photoionization.

9195. **Line broadening,** W. L. Wiese, Book, *Plasma Diagnostic Techniques*, Ed. R. H. Huddleston and S. L. Leonard, **21**, 265-317, (Academic Press, Inc., New York, N. Y., 1965).

Key words: Dense plasma; line broadening; plasma diagnostic techniques; Stark effect.

Line broadening due to interatomic Stark effect, the most important type of line broadening in dense plasmas, has been recently the subject of extensive calculations by Griem, Kolb, Baranger, Shen and others. Subsequent experiments have borne out good agreement with the theoretical results and confirmed the theoretically estimated error limits. Consequently, the measurement of Stark half-widths has emerged as one of the most reliable and convenient methods for the determination of electron densities. Whenever possible, the strong, broad Balmer line *H* should be employed, if necessary by admixing a trace of hydrogen to the plasma. The experimental comparison studies indicate that precise half-width measurements of this line may give electron densities to within 7%. For other hydrogen lines and for isolated lines of heavier elements--if for the latter the results from several lines are averaged--uncertainties not greater than 10 to 15% may be expected. Measurements of Stark shifts of isolated lines should only be used if the shifts are not much smaller than the (half) half-widths. Again, as in the case of the widths, the average value over several lines should be used in order to achieve an accuracy comparable to that mentioned for the widths. Since not many cases of large shifts are known, shift measurements, though appealing in their simplicity, may be only occasionally applied.

An important advantage of the Stark width and shift measurements over other spectroscopic methods is that only relative intensities are required. Moreover, the electron densities from Stark broadening will be reliable even in cases where the existence of LTE is doubtful, while other methods which depend on equilibrium equations are not. The useful range of electron densities extends from 10^{15} cm^{-3} upward, but for the higher hydrogen lines it may be extended about one order of magnitude toward lower densities.

The present situation with regard to Stark broadening is, however, still not satisfactory in some respects: More experimental checks of *H* are desirable to further improve the accuracy of this most important line. Secondly, the Stark parameter calculations should be extended to more elements. Furthermore, to reduce the amount of diagnostic work, it would be desirable to improve the accuracy for a few strong and characteristic lines per element. This is best done experimentally, and the results of the few available studies should be used from this point of view.

9196. **Magnetic core permeability measurement techniques,** R. D. Harrington and A. L. Rasmussen, *Proc. Magnetic Core Conf.* **7**, 11-24 (1965).

Key words: Frequency range; magnetic core; permeability techniques.

Techniques for measuring the initial complex permeability of magnetic cores in the frequency range from 1 kHz to 50 MHz are briefly discussed. Emphasis is directed toward studies recently carried out at the National Bureau of Standards.

At frequencies below 100 kHz, either a demountable coil or a specially designed Maxwell bridge is used for obtaining core data. The frequency range from 100 kHz to about 50 MHz is most conveniently covered through the use of the radio frequency permeameter. A brief survey of the development of the permeameter with a description of some recent measurements indicating that this method may be used to frequencies even greater than 50 MHz is given.

It has been found that toroidal coils are preferable to the permeameter for obtaining accurate measurements of the temperature coefficient of permeability. A brief description is given of a method for evaluating the inductance and resistance changes of such coils using a bridge as a null indicating device. The technique is capable of measuring temperature coefficients of permeability of the order of 10^{-6} per degree centigrade.

9197. **Magnetoacoustic absorption and the Fermi surface in potassium,** H. J. Foster, P. H. Meijer, and E. V. Mielczarek, *Phys. Rev.* **139**, No. 6A, A1849-A1857, (Sept. 1965).

Key words: Fermi surface; magnetoacoustic absorption; potassium; single crystals; zone refining.

Magnetoacoustic measurements in zone refined and oriented single crystals of potassium have yielded detailed information on the relative attenuation, the Fermi surface, and the phase factors in this metal for magnetic field directions lying along the ⟨100⟩, ⟨110⟩, and ⟨112⟩ axes, and within a few degrees on either side of these, perpendicular to a fixed direction of propagation of the longitudinal ultrasonic wave, i.e., q⟨110⟩. The data show that the Fermi surface in potassium is only slightly distorted relative to its free electron value, bulging by about 0.3% in the ⟨110⟩ direction and pushed in by about 0.4% and 0.5%, respectively, in the ⟨100⟩ and ⟨±111⟩ directions within the Brillouin zone (BZ). The distortion in k_f for potassium is therefore found to be less than 1% on the average: $k_f = (7.44 \pm 0.06^*) \times 10^7$ cm^{-1}. The average value of the phase factor for potassium is found to lie rather close to the free electron value of 0.375. (* Estimated limit to experimental error.)

9198. **Measurement of DC dielectric conductance (reciprocal resistance) at elevated temperatures,** A. H. Scott, *Proc. 6th Electrical Insulation Conf.*, Sept. 13-16, 1965, pp. 252-254 (1965).

Key words: Conductance; conductivity; dielectric; measurements; resistance; resistivity.

The new term adopted by Committee D-9 ASTM (DC Dielectric Conductance) for the conductance observed in electrical insulating materials differentiates this type of conductance from that in metals or other conducting materials. Measurements at elevated temperatures require special precautions and special emphasis on some of the usual precautions of measurement. Special cells or holders are required for these measurements.

9199. **Measurement of the 633-nm wavelength of helium-neon lasers,** K. D. Mielenz, R. B. Stephens, K. E. Gillilland, K. F. Nefflen, and R. B. Zipin, *Appl. Phys. Letters*, **7,** No. 10, 277-279 (Nov. 1965).

Key words: Isotopic laser wavelengths; non-isotopic laser wavelengths.

The wavelength of the $3s_2$-$2p_4$ transition of neon was measured by comparison of helium-neon lasers with the Krypton standard of length.

9200. **Measurements of ion-optical properties of a high resolution spectrometer for electron scattering,** S. Penner and J. W. Lightbody, *Proc. Intern. Symp. Magnetic Technologies, Stanford Linear Accelerator Center, Stanford Univ., Calif., Sept. 8-10, 1965*, pp. 154-163 (Oct. 1965).

Key words: Electron scattering; magnetic spectrometer; magneto-optics.

A double focusing magnetic spectrometer for electron scattering work is described. The spectrometer has been ray traced using positive ions from a 400 keV Van de Graaff accelerator. A large number of rays are traced and fitted to a second order transfer matrix by a least squares technique. Selected third order effects are also included. A comparison of measured matrix elements with theoretical predictions is presented. Agreement with theory is good. The intrinsic resolution of the instrument (for a point source) is approximately 1 part in 10^4 FWHM using the maximum solid angle allowed by the vacuum chamber.

9201. **Measurements of the viscosity of parahydrogen,** D. E. Diller, (*Proc. IX Intern. Conf. Low Temperature Physics, Columbus, Ohio, Aug. 31-Sept. 4, 1964*), Book, *Low Temperature Physics*, **LT9,** Part B, 1227-1229 (Plenum Press Inc., New York, N. Y., 1965).

Key words: Liquid normal hydrogen; parahydrogen; shear viscosity; temperature dependence; viscosity of parahydrogen.

The coefficient of shear viscosity η of parahydrogen has been measured by the torsional crystal method at temperatures from 14° to 100 °K and at pressures up to 345 atm. Twenty compressed fluid isotherms encompass the density range 0.003-0.087 g/cm^3 and include the critical region. The precision and accuracy of the measurements is about 0.5%. The temperature dependence of η changes sign at a density approximately twice the critical density. The viscosity at the critical point is estimated to be $35.5 \pm 5 \times 10^{-6}$ g/cm·sec. The viscosity of saturated liquid normal hydrogen is up to 5% greater than that of parahydrogen at the same temperature. Data of this report have been represented within experimental error by an empirical equation of the form $\eta = \eta_0(T) + A(\rho) \exp B(\rho)/T$, where $\eta_0(T)$ is the viscosity in the low-density limit and $A(\rho)$ and $B(\rho)$ are density-dependent coefficients.

9202. **Measuring the coordinates of a number of points in a complex, laboratory-scale model,** F. D. Ordway, *Rev. Sci. Instr.* **36,** No. 8, 1156-1159 (Aug. 1965).

Key words: Calibration points; complex laboratory-scale model; computer; coordinate systems; digital computer; number of points.

Points on the model, together with an array of marked calibration points, are measured with theodolites from two different locations. Distances between a number of pairs of calibration points are measured precisely, and estimates of the distances from the calibration points to the measuring locations are adjusted for the best fit to these precisely measured distances. After adjustment, the distances from calibration points to measuring locations are used to obtain the best estimate of the rotation matrix and translation vector relating the coordinate systems of the two theodolites. The resulting rotation-translation matrix is used with the two sets of angle measurements on each point of the model to obtain the Cartesian coordinates of the point. The Gram-Schmidt orthonormalization procedure is carried out at each step, with a digital computer.

9203. **Metrology essential to the space age,** A. G. McNish, *George Washington Univ. Mag.* **1,** No. 4, 10-14 (1965).

Key words: Modern technology; science comprehension; space age; what is metrology.

Understanding the physical world and the progress of civilization depends upon measurement.

9204. **Microwave spectrum of perchlorylfluoride,** D. R. Lide, *J. Chem. Phys.* **44,** No. 10, 3767-3768 (Nov. 1965).

Key words: Dipole moment; microwave; perchlorylfluoride; quadrupole coupling constant structure.

The microwave spectrum of perchlorylfluoride has been measured and analyzed. Digital averaging techniques were used to improve the signal-to-noise ratio of the very weak lines. The molecular constants determined for $Cl^{35}O_3F$ are $B_0 = 5258.682$, $D_J = 0.0014$, $D_{JK} = 0.0018$, and $eqQ = -19.2$ Mc/s. The OC10 angle is found to be in the range 114°-116°.

9205. **Morphological classification in the National Bureau of Standards mechanical translation system,** L. F. Meyers, *J. Assoc. Compt. Mach.* **12,** No. 4, 437-472 (Oct. 1965).

Key words: Linguistic work; mechanical translation system; morphological classification; translation system.

In linguistic work, morphology is the study of the rules by which words undergo changes in form. Morphological classification is the systematic organization of these rules. A detailed account of the morphological classification for Russian is given as used in the National Bureau of Standards project on the mechanical translation of Russian into English. The account includes the heuristic reasoning from which the classification system evolved, as well as complete classification tables, a description of the method of their construction, and some examples of their use.

9206. **Mossbauer line broadening in SnO_2,** R. H. Herber and J. Spijkerman, *J. Chem. Phys.*, **42,** No. 12, 4312-4314 (June 15, 1965).

Key words: High pressure; line broadening; Mossbauer spectroscopy; quadrupole splitting; stannic oxide.

Since stannic oxide, SnO_2 has been widely used in tin Mossbauer spectroscopy, and has been tentatively adopted as a secondary differential chemical shift standard (Gordon Conference, 1964) a careful study of this compound and its crystal structure has been made. Although published literature describes a single broad resonant absorbtion line, fine structure was observed. The broadening has been interpreted as an unresolved doublet, due to quadrupole splitting, arising from twinning in the (031) plane.

A table of comparison experiments of SnO_2 source or absorber for various tin compounds is included.

9207. **NBS offers method to prevent built-up roof splitting failure,** W. C. Cullen, *Roofing Siding Insulation Mag.* **40,** No. 4, 28-30 (Apr. 1965).

Key words: Built-up roof membrane; innovation; preventive measures; splitting failures; thermal shock.

Innovations in roof design and roofing construction procedures are described. The implementation of one or more of these procedures should reduce premature failures in built-up roofing membranes which are due to thermal contraction in cold climates.

9208. **Newly observed structure in the photoionization continua of Kr and Xe below 160Å,** K. Codling and R. P. Madden, *Appl. Opt.* **4,** 1431-1434 (Nov. 1965).

Key words: Atomic spectra; krypton; photoionization; vacuum ultraviolet; xenon.

The absorption spectra of Kr and Xe have been photographed in the 70-200Å region, revealing many weak, previously unobserved, resonances in the photoionization continua of these gases. The new structures occurring in the 110-115Å region for Kr and 145-160Å for Xe are due to two-electron excitation states involving an inner-shell *d* electron and an outer-shell *p* electron. The resulting configurations are characteristic of the neutral atom, although they lie, in energy, well above the 3rd ionization limits for these atoms. Additional resonances in Xe, photographed in the 90Å region, are due to the excitation of an inner-shell 4*p* electron. An improved value has been obtained for the N_{III} edge of Xe, namely 145.6 (±0.5) eV. These spectra were obtained using the pure continuum radiated by the NBS 180 MeV electron synchrotron as a background source.

9209. **Progress in nuclear instrumentation, 1965 meeting of IEC committee TC45,** L. Costrell, *Mag. Std.* p. 9 (Jan. 1966).

Key words: Modules; nuclear instruments; progress; standards; state-of-the-art.

At the conclusion of World War 11 nuclear instrumentation was to a great extent concerned with detectors that required essentially unsophisticated electronics. The advent of the scintillation counter in the late 1940's called for an order of magnitude improvement in the associated instrumentation. Introduction of the semiconductor radiation detectors with their tremendous energy resolution capabilities stimulated additional sophistication of nuclear electronics.

9210. **Observatory reports, spectroscopy,** C. E. Moore, *Astron. J.* **70,** No. 9, 637-639 (Nov. 1965).

Key words: Atomic spectra; multiplet tables; rare-earth spectra; spectra, far ultraviolet; transition probabilities.

An annual report from the NBS in Washington on spectroscopic research of astrophysical interest, is presented. Analysis of rare-earth atomic spectra and of spectra observed in the far ultraviolet with synchrotron radiation as the source of excitation are discussed. Other topics reviewed briefly are: wavelength standards, transition probabilities, the revised solar table and new multiplet tables. A current bibliography is included.

9211. Unassigned.

9212. **Phase rule considerations and the solubility of tooth enamel,** W. E. Brown and B. M. Wallace, *Ann. N.Y. Acad. Sci.* **131,** Art. 2, 690-693 (Sept. 30, 1965).

Key words: Calcium; hydroxyapatite; phosphate; solubility isotherm.

The phase diagram is a particularly useful means of displaying solubility information because it makes it easier to take into account several variables at one time. The use of the phase diagram is illustrated in connection with the possible reactions hat can take place when NaF - H_3PO_4 solutions are used to treat enamel. A critical quantity proves to be the concentration of Na^+ ion in the treatment solution.

Calcium and phosphorus ions may not diffuse through enamel at the same rates. A situation in which calcium diffuses faster than phosphate would lead to increased concentrations of calcium, phosphate and hydrogen ions within the enamel. This in turn would lead to increased rates of diffusion and dissolution, thus helping to account for subsurface dissolution of enamel.

9213. Unassigned.

9214. **Photon absorption cross section of spherical nuclei,** M. G. Huber, H. J. Weber, M. Danos, and W. Greiner, *Phys. Rev. Letters* **15,** No. 12, 529-531 (Sept. 1965).

Key words: Nuclear physics; photonuclear absorption cross sections; spherical nuclei; theoretical physics.

The Dynamic Collective Theory is extended to vibrational nuclei. The results of the theory are compared with recent photonuclear measurements. Agreement obtains within the accuracy of both the theoretical treatment and the experimental uncertainties. It is concluded that the collective description of the giant resonance is valid in spherical nuclei.

9215. **Photoneutron production by Li^6, Li^7, B^{10}, B^{11}, and O^{16},** E. Hayward and T. Stovall, *Nucl. Phys.* **69,** pp. 241-252 (July 1965).

Key words: Activation curve; cross-section; photoneutron.

The neutron emission cross sections have been measured from targets of Li^6, Li^7, B^{10}, B^{11} and O^{16} when they were irradiated with X-rays in the energy range from 7 to almost 30 MeV. The integrated cross sections are 0.40±0.03, 0.49±0.04, 0.46±0.03, 0.43±0.03 and 0.27±0.02 MeV mb respectively. The average cross sections for the lithium and boron targets appear to be essentially constant in the energy range 25-30 MeV. The data also suggest that the boron cross sections contain a great deal of structure up to the highest energies studied.

9216. **Photonuclear reactions,** M. Danos and E. G. Fuller, *Ann. Rev. Nucl. Sci.* **15,** 29-66 (1965).

Key words: Photon cross-sections; photon scattering; photonuclear absorption; photonuclear reaction.

The development of Photonuclear Physics since the last Annual Reviews report is described. The photon absorption process is treated both in the framework of the shell model and he collective model. The modern computational methods are described from an elementary point of view. The available calculations and experiments are described. Their agreement and their internal consistency is analyzed. The giant resonance region in heavy deformed nuclei seems to be already quite well understood, both experimentally and theoretically. The spherical non-closed shell heavy nuclei have not yet been investigated well enough. For light nuclei, experimental data of reasonable quality exist; the theoretical treatment is, however, not yet adequate. The energy region above the giant resonance is still terra incognita to a large extent.

9217. Unassigned.

9218. **Polymerization and pyrolysis of poly-1,2-dihydronaphthalene,** L. A. Wall, L. J. Fetters, and S. Straus, (*Proc. 150th American Chemical Society Meeting, Atlantic City, N. J., Sept. 12-17, 1965*), *Polymer Preprint* **6**, No. 2, 930-939 (Sept. 1965); *J. Polymer Sci.* Part B; *Polymer Letters* **5**, No. 8, 721-733 (Aug. 1967).

Key words: Degradation; polymerization; pyrolysis; thermal decomposition; thermal volatilization; 1,2-dihydronaphthalene.

Polymerization of 1,2-dihydronaphthalene, using anionic catalysts, gave intractable white powders insoluble in all solvents studied, with the exception of bis(phenoxyphenyl)ether at 290 °C. When dissolved, no appreciable viscosity increments could be detected suggesting either low molecular weights or degradation. In thermal volatilization studies, the polymer yields about 35% monomer and vaporizes at rates near those for polystyrene. Single compacted pellets volatilized faster, however. Unlike the initial powders, pellets had detectable electron spins which could be enhanced by partial pyrolysis. It is concluded that compacting the polymer enhances an exothermic decomposition mechanism.

9219. **Possible nuclear contribution to thermal expansion,** E. C. Hirschkoff and N. M. Wolcott, *Proc. Phys. Soc.* **86**, No. 6, 1372 (1965).

Key words: Ferromagnetism; hyperfine field; NMR; nuclear interaction; nuclear quadrupole resonance; thermal expansion.

A significant contribution to the thermal expansion of a ferromagnetic material at low temperatures due to nuclear interaction with the static hyperfine field is predicted. Some numerical examples are given for cobalt and rare earth metals.

9220. Unassigned.

9221. Unassigned.

9222. **Progress report on a test for cleanability,** M. D. Burdick, *Proc. Porcelain Enamel Inst. Forum*, **26**, 41-48 (1965).

Key words: Cleanability, porcelain enamel surfaces; fluorescent soils; porcelain enamel; soil, residual.

The possible use of fluorescent soils for evaluating the aesthetic cleanability of porcelain enamel surfaces is being explored by the Research Associates. The method being investigated consists of applying a soil containing a small amount of a fluorescent compound to a specimen surface, subjecting the surface to a standard cleaning treatment, and then evaluating the soil remaining on the surface by extracting the residual fluorescent material with toluene and measuring the fluorescence of the resulting solution with a fluorometer. Preliminary results showed that the method was capable of detecting as little as one part per billion of residual soil on a surface. Further work on the method is needed, however, to determine its reproducibility and the degree of correlation of the test data with actual service.

9223. **Progress report on the development of a standardized test for continuity of porcelain enamel coatings,** M. A. Rushmer, *Proc. Porcelain Enamel Inst. Forum*, **27**, 49-56 (1965).

Key words: Bubble structure; continuity of coating; corrosion resistance; high-voltage testing; porcelain enamel; porcelain enamel defects.

Both chemical and electrical methods were investigated for detecting coating discontinuities in porcelain enamels. Chemical methods were found to be time consuming; also, they were incapable of detecting subsurface flaws of a type that can lead to early corrosion of the metal. For these reasons, emphasis was placed on the use of a high-voltage discharge tester. Preliminary work with the tester showed that architectural enamels that rusted in service could be separated from those that did not rust by probing the enamel surface at 1.5 kV. A higher voltage, however, was required to obtain a separation of satisfactory and unsatisfactory hot-water tank enamels. Although these results have been promising, additional work is indicated.

9224. Unassigned.

9225. **Radiation of sound by earthquakes,** R. K. Cook, *5^e Cong. Intern. Acoustique, Liege, Belgium*, 1965, **1b**, K19 (1965).

Key words: Earthquakes, radiation sound; ionospheric motions; radiation sound; sound waves.

Earthquakes cause large motions of the earth's surface which in turn radiate sound waves at infrasonic frequencies into the atmosphere. An analysis of the generation and propagation of sound waves into the upper atmosphere show that substantial ionospheric motions can occur. Such effects occurred during the Alaskan earthquake of March 1964.

9226. **Radiation-induced polymerization at high pressure of 3,3,3-trifluoropropene; 4,4,4,3,3-pentafluorobutene-1; and 5,5,5,4,4,3,3-heptafluoropentene-1,** D. W. Brown (*Proc. 150th American Chemical Society Meeting, Atlantic City, N.J., Sept. 12-17, 1965*), *Polymer Preprint* **6**, No. 2, 965-976 (Sept. 1965).

Key words: Gamma radiation; polymerization; pressure; poly-5,5,5,4,4,3,3-heptafluoropentene-1; poly-4,4,4,3,3-pentafluorobutene-1; poly-3,3,3-trifluoropropene.

The kinetics of the gamma-ray-induced polymerization of 3,3,3-trifluoropropene; 4,4,4,3,3-pentafluorobutene-1; and 5,5,5,4,4,3,3-heptafluoropentene-1 were investigated within the overall pressure range 1,800-15,000 atm and temperature range 21-161 °C. The polymerizations are free radical in character. Their activation enthalpies, volumes, and entropies increase in the order: propene, butene, pentene. The maximum polymerization rates observed exceeded 10%/hr. for each monomer at a dose rate of 1,500 rad/hr. The maximum intrinsic viscosities were 5.2 dl/g for polytrifluoropropene, 0.67 dl/g for polypentafluorobutene, and 0.12 dl/g for polyheptafluoropentene. The monomer transfer constant of 3,3,3-trifluoropropene was determined. Values range from 10^{-6} to 4 x 10^{-3}, increasing with temperature increases at constant pressure and with pressure decreases at constant temperature. Transfer effectively determines the molecular weight of polytrifluoropropene at temperatures above 70 °C; the molecular weights of the other polymers are probably determined largely by transfer under all the experimental conditions studied.

9227. **Relation of strength of thermally tempered glass to fracture mirror size,** M. K. Kerper and T. G. Scuderi, *Am. Ceram. Soc. Bull.* **44**, No. 12, 953-955 (Dec. 1965).

Key words: Fracture mirror size; modulus rupture; thermally tempered glass.

The typical fracture of glass broken in flexure has a smooth area which includes the fracture origin. The size of this smooth area or "mirror" is dependent upon the stress introduced in the glass by the thermal tempering process as well as that resulting from flexure during testing of the specimens. The sizes of the mirror in fractures originating on the surface of annealed, semi-tempered or tempered specimens shows a relationship to the modulus of rupture of each type of specimen. This is also true for fractures originating at the edge of annealed glass. For fractures originating at the edge of semi-tempered and tempered glass there is no consistent relationship between mirror size and modulus of rupture.

9228. **Scattering properties of concentric soot-water spheres for visible and infrared light,** R. W. Fenn and H. Oser, *J. Appl. Opt.* **4,** 1504-1509 (Nov. 1965).

Key words: Cloud physics; infrared light; light scattering; Mie Theory; scattering functions.

Based on the theory by Aden and Kerker, computations of the scattering and absorption properties for concentric spherical water-and-particles have been performed for visible and infrared wave lengths. Computations were performed for size parameter values up to 250. Results indicate that, for compound particles with a nucleus smaller than about one-tenth of the total diameter of the particle, the optical properties are almost completely determined by the outer shell. Some results of the computations are presented in graphical form for the scattering and absorption efficiency factors and the angular scattering functions.

The frequency dependence of the complex dielectric constant is not taken into account in the actual computations: absorption, scattering and total extinction are given for constant index of refraction. The theory does allow to take this dependence into account, however, if one wishes to do so.

9229. **Silicon-fluorine chemistry. II. Silicon-boron fluorides,** P. L. Timms, T. C. Ehlert, J. L. Margrave, F. E. Brinckman, T. C. Farrar, and T. D. Coyle, *J. Am. Chem. Soc.* **87,** No. 17, 3819-3823 (Sept. 1965).

Key words: Boron; fluorine; NMR; polysilanes; silicon; sub-halides.

Silicon difluoride reacts with boron trifluoride, producing a series of compounds with silicon-boron bonds. Nuclear magnetic resonance studies of the compounds Si_2BF_7 and Si_3BF_9 indicate that these are to be formulated as perfluorodisilanylboron difluoride and perfluorotrisilanylboron difluoride respectively. Physical and chemical studies of these new materials are reported.

9230. **Solid-vapor equilibrium in the system helium-methane,** M. J. Hiza and A. J. Kidnay, (*Proc. 1964 Cryogenic Engineering Conf., University of Pennsylvania, Philadelphia, Pa., Aug. 18-24, 1964*), Book, *Advances in Cryogenic Engineering* **11,** 338-348 (Plenum Press, Inc., New York, N. Y., 1966).

Key words: Experimental; helium-methane; low temperature; phase-equilibrium; solid-vapor.

Gas phase compositions in the solid-vapor region for the helium-methane system have been measured at seven integral temperatures from 55.00° to 87.00 °K up to 140 atmospheres pressure. Measurements were also made in the liquid-vapor region at 91.00 °K to provide a direct comparison with the only other gas phase data for this system available in the literature. A flow system was used in which methane was evaporated into a pure helium gas stream. The gas phase leaving the equilibrium cell was analyzed continuously with a hydrogen flame-ionization detector. The data obtained are presented in both tabular and graphical form. Comparison of 91.00 °K data from the present investigation with the data from the literature at 91.1 °K shows a disagreement between the two sets by as much as a factor of four.

9231. **Some applications of the wave front shearing interferometer,** J. B. Saunders, *Japanese J. Appl. Phys. Suppl.* **1, 4,** 99-105 (1965).

Key words: Interferometer; lens aberrations; prism interferometer; testing of lenses.

This paper gives the results of several applications of the wave front shearing prism interferometer. The instrument is very compact and easy to apply. It is applied to the testing of chromatic aberration of simple and compound lenses; and to the testing of wave forms that characterize the monochromatic aberrations (spherical, coma and astigmatism). Results are shown for several different type lenses. This interferometer is equally applicable to the testing of small lenses and large telescope objectives.

9232. **Some statistical properties of pulses from photomultipliers,** M. Gadsden, *Appl. Opt.* **4,** No. 11, 1446-1452 (Nov. 1965).

Key words: Noise, signal; photomultipliers; signal noise ratio; statistical properties; time intervals.

An examination of the integrated counts from 9502S and 9558A photomultipliers suggests that the statistical distribution is closely Poissonian. An examination of the time intervals between consecutive pulses has shown an interesting effect: with a 9502S tube, a highly significant, although small, number of intervals are much longer than expected on a random hypothesis. This effect is explicable in terms of a loss of electrons between cathode and anode. Data on the variation of the signal:noise ratio with differing discriminator bias levels are also presented.

9233. **SPACEWARN--An international mechanism for rapid distribution of information on satellites and space probes,** A. H. Shapley, *COSPAR Info. Bull.* **24,** 30-55 (July 1965).

Key words: Radio service; satellites and space probes; space and satellites.

9234. **Specification for dry cells and batteries,** W. J. Hamer, *ASA* **C18.1,** pp. 31 (1965).

Key words: Batteries; battery classification; battery performance; battery terminals; battery tests; battery types.

This standard for dry cells and batteries includes nomenclature, sizes, tests, and performance data on (1) Leclanche cylindrical cells, (2) Leclanche flat cells, (3) mercury cells, (4) silver oxide button cells, (5) alkaline manganese dioxide cells, (6) sealed nickel-cadmium cells, and on various types of batteries made with the above types of cells. The types of batteries covered include (1) lighting batteries, (2) safety-flasher batteries, (3) transistor hearing-aid batteries, (4) general transistor batteries, and (5) high- and low-voltage batteries. The tests are designed to evaluate the performance of the cells and batteries under simulated service conditions. Descriptions and drawings of various classes of terminals are given.

9235. **Spectrochemical analysis of high-temperature alloys by spark excitation in argon and nitrogen,** H. C. Dilworth, *Am. Soc. Testing Mater. Spec. Tech. Publ.* **376** (1965).

Key words: Alloys, high-temperature; ambient air; argon; atmospheres of argon; high-temperature alloys; nitrogen; nitrogen and ambient air; spark excitation.

Spark excitation of high-temperature alloys in atmospheres of argon, nitrogen, and ambient air were investigated. Compared to air, argon or nitrogen provide the following advantages: (1) Volatilization rates are more constant in time. (2) Background intensities are constant and independent of alloy composition. (3) Effects of metallurgical history on specimen excitation are minimized. Also, self-absorption is markedly reduced in argon. Because of these characteristics, calibration is simplified, and it is possible to analyze many different types of alloys with the same set of analytical curves. This results in a marked reduction in the number of primary standards needed for initial calibration. An effective device for shielding the spark excitation column and specimen surface with a stream of gas is described. Data are presented showing application of the method of excitation in argon and nitrogen to the analysis of a variety of high-temperature alloys.

9236. **Spin-lattice relaxation of rare earth ions in LaCl$_3$,** B. W. Mangum and R. P. Hudson, *Bull. Am. Phys. Soc. Series II*, **10,** No. 8, 1109 (Oct. 1965).

Key words: Rare-earth; spin-lattice relaxation.

Studies of spin-lattice relaxation of the ions Ce^{3+}, Nd^{3+}, Sm^{3+}, Ho^{3+}, and Er^{3+} present in low concentrations (0.2 to 2 per cent) in the host lattice of LaCl$_3$ have been made in the liquid helium region by the pulsed-microwave method. The variation of the relaxation time, τ, with temperature permits separation of the contributions to the relaxation from the two-phonon (resonant and non-resonant) and single phonon processes.

The substances studied are not "well-behaved"; features such as non-exponential decays and variability of the derived values for the splitting between the ground and first excited levels are discussed. Some of the ions exhibit a significant variation of τ with concentration and Nd^{3+} shows an interestingly large anisotropy of τ in the Raman process.

9237. **Standard frequency and time services of the National Bureau of Standards,** D. H. Andrews, *Frequency* **3,** No. 6, 30-35 (Nov.-Dec. 1965).

Key words: Broadcast of standard frequencies; high frequency; low frequency; standard frequencies; time signals; very low frequency.

Detailed descriptions are given of eight technical services provided by the National Bureau of Standards radio stations WWV, WWVH, WWVB, and WWVL. These services are: 1. Standard radio frequencies; 2. Standard audio frequencies; 3. Standard musical pitch; 4. Standard time intervals; 5. Time signals; 6. UT2 corrections; 7. Radio propagation forecasts; and 8. Geophysical alerts.

9238. **Standardization of the differential chemical shift for Fe^{57},** J. J. Spijkerman, F. C. Ruegg, and J. R. DeVoe, (*Proc. New England Nuclear Mossbauer Symp., New York, N.Y., Jan. 1964*), Book, *Mossbauer Effect Methodology*, pp. 115-120 (Plenum Press, Inc., New York, N. Y., 1965).

Key words: Crystal structure; differential chemical shift; Mossbauer spectroscopy; quadrupole splitting; sodium nitroprusside; standardization.

To provide Mossbauer data for Fe^{57} on a uniform basis, to eliminate recalculation of data from various laboratories, and to provide tables of Mossbauer spectra, the National Bureau of Standards has included disodium pentacyanonitrosylferrate dihydrate, Na$_2$[Fe(CN)$_5$NO]·2H$_2$O, in the Standard Reference Materials Program. Single crystals of sodium nitroprusside will be available by April 5, 1965 for this standardization. The crystals are supplied by a commercial manufacturer, and calibrated by NBS on a Mossbauer spectrometer, using an optical fringe counting technique.

The Mossbauer spectrum of a single crystal absorber, cut along the bc plane, is a well resolved, symmetric doublet. The center of this doublet is defined as the zero reference point for the differential chemical shift, with the containing absorber at 25.0 °C. The absorber crystals supplied will be 1cm x 1cm, with 25.0 mg/cm^2 of natural iron.

9239. **The ultrasonic velocity in fluid parahydrogen,** B. A. Younglove, (*Proc. IX Intern. Conf. Low Temperature Physics, Columbus, Ohio, Aug. 31-Sept. 4, 1965*), Book, *Low Temperature Physics* **LT9,** Part B, 1223-1226 (Plenum Press, Inc., New York, N. Y., 1965).

Key words: Adiabatic compressibility; hydrogen; sonic velocity.

The ultrasonic velocity in fluid parahydrogen has been measured in the temperature range 15° to 100 °K and in the density range 0.015 to 0.085 gm/cm^3. Also the ultrasonic velocity in normal and parahydrogen of the saturated liquid has been measured between 14.5 ° and 32.2 °K. The measurements in the compressed liquid were made either on isochores or isotherms as desired. The density at each point was calculated from the thermodynamic data of Goodwin, et al.

Ten megacycle crystals were used to generate and receive the sound by the pulsed method of Greenspan and Tschiegg in their measurements on water. In system tests using water good agreement was obtained. Standing wave measurements that were taken on the saturated liquid also agree well with the pulsed method. The results are compared with the velocity calculated from PVT and C_v measurements of this laboratory and with measured values from the laboratory of A. Van Itterbeek.

9240. **Superconducting behavior of indium-lead alloys,** S. Gygax, J. L. Olsen, and R. H. Kropschot, (*Proc. IX Intern. Conf. Low Temperature Physics, Columbus, Ohio, Aug. 31-Sept. 4, 1964*), Book, *Low Temperature Physics* **LT9,** Part A, 587-590 (Plenum Press, Inc., New York, N. Y., 1965).

Key words: Ginzburg Landau theory; indium lead alloys; superconductivity.

In a recent publication Saint-James and de Gennes have pointed out that thin superconducting regions can exist close to the surface of a superconductor in a magnetic field H_{c3} which is higher than the upper critical field H_{c2} given by the Ginzburg Landau theory. They find $H_{c3}=1.691\ H_{c2}$.

We have measured the temperature dependence and concentration dependence of H_{c1}, H_c, H_{c2}, and H_{c3} on polycrystalline indium lead alloys in the α phase region. The experimental value found for H_{c3} is within 10% of the theoretical value and the experimental values of K agree very well with the Ginzburg Landau theory.

9241. **Suppression of 60 c/s pickup when using sensitive DC amplifiers,** R. L. Nutall and D. C. Ginnings, *Electron. Design* **12,** No. 26, 34-35 (Dec. 20, 1965).

Key words: DC-amplifiers; filter; pickup.

Measurements with two commercial low-level DC amplifiers have shown that the use of simple one-stage series-resonant input filter (RLC) enables them to be used with 60 c/s pickup signals as large as volts, contrasted with tolerances of millivolts without the filter. The use of the filter also permits the amplifiers to be used in the presence of 60 c/s pickup with relatively high DC signal source impedances.

9242. **Tables of dielectric constants, dipole moments and dielectric relaxation times,** F. I. Mopsik, (*1964 Digest of Literature on Dielectric Conf. Electrical Insulation*), Natl. Acad. Sci.-Natl. Res. Council Publ. No. **1342,** 28, (Natl. Acad. Sci.-Natl. Res. Council, Washington, D. C., 1965).

Key words: Dielectric constants; dielectric relaxation times; dipole moments.

Dielectric constant and dipole moment data have been compiled from the 1964 literature. Much of the work continues in the regions of interest of the previous years. The most noteworthy measurement appears to be the detection of a dipole moment in deuterated acetylene due to isotopic substitution.

9243. **Tapered inlets for pipe culverts, discussion and author's closure,** J. L. French, *J. Hydraulics, Div. Am. Soc. Civil Eng.*, 286 (May 1965).

Key words: Culverts; hydraulics; inlets; model tests.

The original paper by the writer appeared in the March 1964 issue of the Journal of the Hydraulics Division, ASCE.

Discussions of the paper appeared in the November issue of the Journal, and the writer's closing discussion will appear in the March or May 1965 issue. The present digest of the paper is for Transactions, ASCE.

9244. **The ADI auxiliary publications program,** R. W. Zimmerer, *IEEE Trans. Microwave Theory Tech.* MTT-13, No. 6, 883-884 (Nov. 1965).

Key words: Documentation; information retrieval; publication.

A short Letter to the Editor of IEEE-MTT concerning The American Documentation Institute's Auxiliary Publications Program at the Library of Congress where the editor of any recognized journal can deposit documents with the Photoduplication Service. This letter recommends that the IEEE-MTT Journal start using this service.

9245. **The calibration of permanent magnet standards,** I. L. Cooter, (*ISA 20th Annual Conference and Exhibit, Los Angeles, Calif., Oct. 4-7, 1965*), *ISA Preprint* **14.1**-3-65 (1965).

Key words: Calibration, permanent magnet standards; magnet standards; permanent magnet standards; reference magnets.

The increased demand for the calibration of permanent magnets used as reference standards has required a new magnet calibration facility at the National Bureau of Standards, Washington, D. C. The method procedure and apparatus used in the calibration of reference magnets are described.

9246. **The correlation of experimental pressure-density-temperature and specific heat data for parahydrogen,** H. M. Roder, L. A. Weber, and R. D. Goodwin, (*Proc. XI Intern. Congress Refrigeration, Munich, Germany, Aug. 1963*), Book, *Progress in Refrigeration Science and Technology* **1**, 187-191 (Pergamon Press Inc., New York, N. Y., 1965).

Key words: Density; heat of vaporization; hydrogen; parahydrogen; specific heat; thermodynamic function.

The use of hydrogen in space vehicles and in nuclear devices demands precise knowledge of its mechanical and thermal properties.

The mechanical properties for parahydrogen are defined by nearly 1200 closely spaced experimental P-ρ-T points. The boundaries in temperature are 14° and 100 °K, while the experimental pressure ranges from 2 to 350 atm. The P-ρ-T surface was approximated by a large number of polynomials coupled with appropriate interpolation schemes. Use of the virial expansion allows extrapolation to pressures below 2 atm.

Thermal properties may be obtained after relating the experiment above to a second one in which the heat capacity at constant volume was determined for a variety of experimental conditions. At temperatures below critical these heat capacities are used as primary data, while at temperatures above critical they serve as check on the correlation between the statistically calculated specific heats and the P-ρ-T data. Further tests of the correlation arise when calculating thermodynamic functions.

As a result of this correlation it is now possible to compute as function of pressure and temperature such quantities as specific volume, enthalpy, entropy, specific heat at constant volume, specific heat at constant pressure, sonic velocity, the Joule-Thompson inversion, and the heats of vaporization.

9247. **The design of a federal statistical data center,** E. Glaser, D. Rosenblatt, and M. K. Wood, *Statistical Evaluation Report* No. 6, Office of Statistical Standards, Bureau of the Budget, Appendix C, pp. 1-19 (Office of the President, Washington, D. C., Dec. 1965).

Key words: Automatic data processing equipment; confidentiality audits; disaggregation; disclosure criteria; Federal statistical system; inherent computability; matching; probability master samples; propagation of error computations; statistical standards.

This paper treats the principles underlying the design of a Federal Statistical Data Center intended to provide a better integrated information network for use by Government, industry, and the research community in an age of large-scale computers.

9248. **The dielectric polarizability of fluid parahydrogen,** J. W. Stewart, (*Proc. IX Intern. Conf. Low Temperature Physics, Columbus, Ohio, Aug. 31-Sept. 4, 1965*), Book, *Low Temperature Physics* LT9, Part B, 1230-1232 (Plenum Press Inc., New York, N. Y., 1965).

Key words: Dielectric polarizability; dipole moment; fluid parahydrogen; macroscopic polarizability.

In the case of nonpolar substances such as hydrogen the macroscopic polarizability (induced dipole moment per unit mass per unit electric field) P is related to the dielectric constant ϵ and the density ρ through the Clausius-Mossotti equation:

$$P=\frac{\epsilon-1}{\epsilon+2}\cdot\frac{1}{\rho}\quad.$$

Elementary theory predicts that the righthand side of the equation, often called the Clausius-Mossotti function, should be a constant independent of density. Detailed verification of this requires accurate measurements of both ϵ and ρ over as wide a range of conditions as possible. Sufficiently accurate measurements of ρ have previously been available for *normal* hydrogen, but a really meaningful investigation of the constancy of P for fluid parahydrogen over a wide range of density in both the gaseous and liquid states has been made possible only recently by the high-precision density measurements in this laboratory by Goodwin and his co-workers. Their values of ρ are estimated to have an absolute precision of better than 0.1%. They are internally consistent to 0.02%. For corresponding precision in the calculated values of P, the dielectric constant must be determined to considerably higher accuracy.

9249. **The effect of insulation on the weathering of smooth-surfaced built-up roofs exposed to solar heating,** W. C. Cullen and W. H. Appleton, *Coal Tar Asphalts Related Mater.* 3, 122-124 (Mar. 1965).

Key words: Built-up roofing; deterioration insulation; radiative cooling; solar heating.

The effects of solar heating on the weathering characteristics of smooth-surfaced, built-up roofings applied over insulation are discussed. Data are presented giving the temperatures attained at the underside of smooth-surfaced, built-up roofings placed either over insulation or directly on a concrete deck. Photographs are given showing the differences in the weathering between the insulated and non-insulated roofings observed in the laboratory and in the field. The data show that roofings placed over insulation are subjected to much higher maximum temperatures, more rapid temperature changes, and greater sub-cooling on clear nights than similar roofings placed directly on concrete decks.

9250. **The interaction of radiation with charged particles. I,** W. R. Chappell, W. E. Brittin, and S. J. Glass, *Il Nuovo Cimento* **38**, No. 3, 1186-1191 (Aug. 1965).

Key words: Charged particles; electrons and photons; interaction of radiation; radiation, charged particles.

We employ the Bogoliubov-Tyablikov transformation and an equation of motion method, utilizing part of the Hamiltonian for a system of interacting electrons and photons, to obtain the familiar dispersion relation, $\omega^2 = k^2c + \omega p^2$, for a system of quasi-photons. The equation of motion method can be used to obtain an extended dispersion relation when more terms of the Hamiltonian are taken into account.

9251. Unassigned.

9252. **The important atmospheric processes in the D region,** G. C. Reid, *Proc. COSPAR Polar Cap Panel Symp., Alpach, Austria, 1964*, pp. 15-19 (Academic Press Inc., New York, N. Y., 1965).

Key words: D region; ionosphere; negative ions; photodetachment; recombination.

This is a summary of a review paper delivered at the Symposium on High-Latitude Particles and their Effects on the Polar Ionosphere. Current knowledge of D-region reactions is reviewed and outstanding problems are discussed.

9253. **The microwave spectrum of dinitrogen trioxide,** R. L. Kuczkowski, *J. Am. Chem. Soc.* **87**, 5259-5260 (1965).

Key words: Dinitrogen trioxide; equilibrium; microwave spectrum; structure.

The microwave spectrum of four isotopic species of dinitrogen trioxide is reported which support the planar $ON\text{-}NO_2$ model with C_S symmetry and from which the N-N bond is determined to be 1.85 with an estimated uncertainty of ±0.03Å.

9254. **The monomer-polymer equilibrium of α-trideuteromethyl-β,β-dideuterostyrene,** L. J. Fetters and L. A. Wall, (*Proc. 150th American Chemical Society Meeting, Atlantic City, N. J., Sept. 12-17, 1965*), *Polymer Preprint* **6**, No. 2, 899-903 (Sept. 1965).

Key words: Equilibria; equilibrium concentration of monomer; α-trideuteromethyl-β,β-dideuterostyrene; lowering of steric repulsions; polymeric anion; ΔH; ΔS.

The equilibria between α-trideutero-methyl-β,β-dideuterostyrene and its polymeric anion in tetrahydrofuran has been investigated between 262 and 308 °K. The heat and entropy changes were both increased significantly by the deuteration. Qualitatively the effect observed appears best explained by the premise that a lowering of steric repulsions occurs with deuterium; and hence the effective volume for deuterium is less than that for hydrogen.

9255. **The NBS cryogenic data center,** V. J. Johnson, (*Proc. XI Intern. Conf. Refrigeration, Munich, Germany, 1963*), Book, *Progress in Refrigeration Science and Technology*, **1**, 110-114 (Pergamon Press, Oxford, England, 1965).

Key words: Cryogenic data center; cryogenic fluids; low temperature properties of materials; NBS cryogenic data center; thermodynamic and transport properties.

A brief description is given of the two principal activities of the Cryogenic Data Center, namely: the evaluation and compilation of data on low temperature properties of materials; and the acquisition, handling and dissemination of technical literature. A program for thorough evaluation and the compilation of thermodynamic and transport properties of cryogenic fluids and selected solids is mentioned. Four functions of the literature service are outlined and typical pictures of the operation included.

9256. **The NBS instrumentation for use in the measurement of spectral irradiances of solar simulators,** R. Stair and W. E. Schneider, *Proc. Intern. Symp. Solar Radiation Simulation, Los Angeles, Calif.*, Jan. 18-20, 1965, pp. 75-94 (Inst. Environmental Sciences and Am. Soc. Testing and Materials, 1965).

Key words: Integrating sphere; solar simulator; spectroradiometer; standard of spectral irradiance.

Three methods are described for the measurement of the spectral irradiances of solar simulators at the National Bureau of Standards. The design of acceptable equipment is significantly affected by large variations in sensitivity of photoelectric and thermoelectric detectors with the wavelength and over their surfaces. The first instrumentation consists of a conventional spectroradiometer in which the source flux is collected in an integrating sphere which insures accurate evaluation of the solar simulator flux in terms of that from a 1000-watt lamp standard of spectral irradiance. A MgO-coated sphere is used for the ultraviolet, visible and near infrared to 1.6 microns.

9257. **The radiation induced polymerization of hexafluoropropylene at high temperature and pressure,** R. E. Lowry, D. W. Brown, and L. A. Wall, (*Proc. 150th American Chemical Society Meeting, Atlantic City, N. J., Sept. 12-17, 1965*), *Polymer Preprint* **6**, No. 2, 977-984 (Sept. 1965), *J. Polymer Sci.* **4**, Part A-1, No. 9, 2229-2240 (Sept. 1966).

Key words: Activation enthalpy; hexafluoropropylene; high pressure; intrinsic viscosity; radiation induced polymerization; radiation intensity.

The radiation-induced polymerization of hexafluoropropylene was studied in the pressure and temperature range 4,500-15,000 atm and 100-230 °C, respectively. Retardation was a serious problem: data thought to apply to the unretarded polymerization are summarized below. At 1,500 rad/hr the polymerization rate was 15%/hr at 230 °C and 15,000 atm. The activation enthalpy and volume are 9.5 kcal/mol and -10 cc/mol respectively. The rate varies as the square root of the radiation intensity. The largest intrinsic viscosity of the polymer is 2.0 dl/g; values increase with temperature and pressure. At 130 °C and 10,000 atm the intrinsic viscosity was the same at two radiation intensities.

9258. **The response of flush diaphragm pressure transducers to thermal gradients,** L. Horn, (*20th Annual ISA Conference and Exhibit, Los Angeles, Calif., Oct. 4-7, 1965*), *Preprint No.* **13.3-4-65** (1965).

Key words: Flush diaphragm; pressure gage; temperature; temperature gradient; transducers.

The zero signal output of pressure transducers may alter during field use in the presence of thermal gradients. The changes can be large enough to cause serious questioning of the validity of test data taken without corrections for the zero shift.

Variations of up to 100% FS (full scale) have been found using transducers that indicated less than a 6% shift in the standard steady state temperature tests.

A simple method of dynamic testing is described and experimental results are given for a number of tests.

9259. **The theory of the chromospheric spectrum,** J. T. Jefferies, Book, *The Solar Spectrum*, Ed. C. DeJager, 131-150 (D. Reidel Publ. Co., Dordrecht, The Netherlands, 1965).

Key words: Chromospheric flash spectrum; chromospheric spectrum; solar disk; spectrum.

The article reviews the problems of interpretation of (a) weak lines in the chromospheric flash spectrum and (b) strong lines whose profiles are measured from center to limb on the solar disk. Typical methods for these interpretations are considered and new ones put forward. Outstanding problems are delineated.

9260. Unassigned.

9261. Unassigned.

9262. Unassigned.

9263. **Thermodynamics of the rigid-rotor at high temperature,** J. E. Kilpatrick, Y. Fukuda, and S. Y. Larsen, *J. Chem. Phys.* **43**, No. 2, 430-432 (July 1965).

Key words: Rigid-rotor, high temperatures; thermodynamic properties; thermodynamics, rigid-rotor.

It is shown that Q_e, the partition function for a rigid-rotor summed over even levels and Q_0, summed over odd levels, have exactly the same asymptotic (power series in $\sigma=\hbar^2/2IkT$) expansion. No information as to differences in thermodynamic properties due to spin and statistics can be obtained from this expansion. The exchange partition function, Q_e-Q_0, is calculated directly and used to give simple expressions for the differences in thermodynamic properties between the *para*, *ortho*, and equilibrium cases.

9264. **Thermolytic chain scission of linear polyethylene and an ethylene-propylene copolymer,** H. Yu and L. A. Wall, (*Proc. 150th American Chemical Society Meeting, Atlantic City, N. J., Sept. 12-17, 1965*), *Polymer Preprint* 6, No. 2, 940-944 (Sept. 1965).

Key words: Copolymer; ethylene-propylene; linear polyethylene; stress relaxation; thermolytic chain scission.

Thermolytic chain scission of a linear polyethylene and (70:30) ethylene-propylene copolymer was studied with the stress relaxation in vacuo at 260 ~ 320 °C. The mode of thermolytic chain scission is random along the backbone carbon-carbon bonds. The activation energy for the ethylene-propylene copolymer is found to be 42 kcal/mol; 73 kcal/mol for linear polyethylene. The results for the polyethylene are in agreement with those obtained by the study of rate of volatilization at 400 ~ 420 °C.

9265. Unassigned.

9266. **Voltmeter calibration to 1 GHz,** M. C. Selby, W. J. Blank, and R. P. Chariton, (1965 Wescon Conference, San Francisco, Calif., August 1965), *IEEE WESCON Tech. Papers* **9**, Part 6, No. 8.8, 1-12 (1965).

Key words: Calibration, high-frequency voltages; measurement, microwave voltages; voltage, high-frequency, calibration; voltage measurements; Voltage Tee.

A novel Voltage Tee to calibrate meters to 1 GHz is described. It eliminates errors caused by standing waves over an extremely wide range of voltmeter input impedances. It considerably reduces the RF calibration power required, as compared with conventional matched Tees.

9267. **Winter anomaly in ionospheric absorption and stratospheric warnings,** A. H. Shapley and W. J. G. Beynon, *Nature* **206**, 1242-1243 (June 1965).

Key words: Absorption, ionospheric; ionospheric absorption; stratospheric warnings; winter anomaly.

9268. **Methods of determining Coriolis zeta constants,** S. Abramowitz and I. W. Levin, *J. Mol. Spectry.* **19**, No. 4, 461-462 (Apr. 1966).

Key words: Band contours; BF_3; Coriolis force; force fields; high resolution; infrared; ν_3; vibration-rotation; ζ_3; ζ_4.

The recently observed high resolution spectrum of the ν_3 fundamental of BF_3 has been interpreted to yield a Coriolis ζ constant in agreement with that found from an investigation of the unresolved band contour.

9269. **Magnetization and critical fields of superconducting $SrTiO_3$,** E. Ambler, J. H. Colwell, W. R. Hosler, and J. F. Schooley, *Phys. Rev.* **148**, No. 1, 280-286 (Aug. 5, 1966).

Key words: Critical fields; heat capacity; magnetization curves; semiconducting $SrTiO_3$; superconducting $SrTiO_3$.

Magnetization curves from T=0.15 °K to T_c have been measured for two specimens of semiconducting $SrTiO_3$ of electron density about 10^{20} cm^{-3}. Magnetic hysteresis was observed in each case. The temperature dependences of the first and second critical fields have been measured. The heat capacity has been measured down to 0.3 °K for one specimen, yielding γ, the coefficient of the linear term, and an independent value of T_c at the upper part of the specific heat anomaly. Values of H_c (0) derived on the basis of the heat capacity data are higher than the values of $H_c(0)$ obtained from the magnetization data. The Ginzburg-Landau k is shown to vary inversely with the electronic mobility, as expected.

9270. **The determination of heats of formation of refractory compounds,** G. T. Armstrong and E. S. Domalski, *Proc. 4th Meeting Interagency Chemical Rocket Propulsion Group, Working Group on Thermochemistry, Kennedy Space Flight Center, Florida*, March 16-18, 1966, **I**, No. 108, 15 (Chemistry Propulsion Information Agency, Silver Spring, Md., June 1966).

Key words: Aluminum borides; boron; boron carbide; carbon; fluorine; heat of combustion; polytetrafluoroethylene (Teflon); refractory compounds.

Refractory compounds have an application in propellants as possible ingredients of air breathing engines. In a study carried out for the Air Force Aero Propulsion Laboratory, Wright Patterson Air Force Base, the heats of combustion of several boron compounds in fluorine were studied with a view to determining their heats of formation from the elements. To determine auxiliary data for calculating the heats of formation of the compounds, the heats of combustion of fluorine of polytetrafluoroethylene (Teflon), graphite, and boron were determined also. Analysis of the compounds becomes a major problem in deriving heats of formation from the observed calorimetric data. The effects of analysis in the interpretation of the data are discussed. The presentation is in the nature of a summary. Details will be presented in projected publications.

9271. **What environment--for whom?** G. E. Auman, *Civil Service J.* **7**, No. 1, 6-11 (July-Sept. 1966).

Key words: Environment; personnel; professional environment; professional personnel; scientists and engineers; standing committee; technical personnel.

Since the early 1960's the Standing Committee of the Federal Council for Science and Technology has been studying, analyzing and making recommendations designed to improve the environment for Federal scientists and engineers. During 1965 the Committee queried 1,025 scientists and engineers in 17 Federal laboratories concerning the importance of 51 carefully selected environmental features and their satisfaction with provision of these features in the Federal service. The survey revealed extreme variations in the attitudes of respondents with regard to virtually every item. However, some clearly defined patterns and relationships among subgroups were identified when respondents were subclassified by discipline, education, grade level, type of work performed, employing laboratory, etc.

Overall the features ranking highest in importance were those concerned with professional values, appropriate and equitable pay, and adequate on-the-job support. Some items of generally low importance were patent rights, separate classification titles for scientists and engineers, security controls and sabbatical leave. In view of the wide disparity in satisfaction expressed by persons in individual laboratories and subgroups, it is suggested that agencies and laboratory directors might profitably undertake similar surveys and specific improvement programs for their installations.

9272. **Photoionization of *n*-butane at 1067-1048 Å, Decomposition of the parent ion and superexcited molecule,** P. Ausloos and S. G. Lias, *J. Chem. Phys.* **45,** No. 2, 524-535 (July 15, 1966).

Key words: Butane; ionization efficiency; ion-molecule reactions; ion-pair yields; photoionization; superexcited molecule.

n-C_4D_{10}, *n*-C_4D_{10}, $CD_3CH_2CH_2CD_3$, and C_4D_{10} - C_3D_6 mixtures have been irradiated in the presence of oxygen with the argon resonance lines at 1067 Å and 1048 Å. On the basis of saturation ion current measurements, the ionization efficiency ratios η_{C4D10}/η_{NO} and $\eta_{NO}\eta_{C4H10}/\eta_{NO}$ were estimated to be 0.48 ±0.003 and 0.465±0.003, respectively. It is demonstrated that at the argon resonance lines the $C_4H_{10}^+$ ion undergoes fragmentation according to the following two processes:

$$\begin{aligned} C_4H_{10}^+ &\rightarrow C_3H_7^+ + CH_3 \\ &\rightarrow C_3H_6^+ + CH_4 \end{aligned}$$

The isotopic analysis of the propane fraction formed in the irradiation of *n*-C_4H_{10}-*n*-C_4D_{10}-O_2 mixtures indicates that the propyl ion which reacts with *n*-butane to form propane by a H^- or D^- ion transfer has the *sec*-propyl ion structure. It is further shown that, in agreement with recent studies on ion-molecule reactions, the $C_3H_6^+$ ion also reacts with C_4H_{10} to form C_3H_8 (H_2^--transfer). The yield of the parent ion was estimated by making use of the recently established H_2-transfer reaction: $C_4H_{10}^+ + C_3D_6 \rightarrow CD_3CDHCD_2H + C_4H_8^+$.

The fragmentation of the butane parent ion is strongly quenched by an increase in the pressure of butane, or upon addition of an inert gas. The following approximate relative efficiencies for the quenching of the fragmentation of the excited $C_4D_{10}^+$ ion are obtained: He - 1, N - 5, C_4D_{10} - 35. It is also noted that the fragmentation of the $C_4D_{10}^+$ ion is more readily quenched by collision with He than that of the $C_4H_{10}^+$ ion by about a factor of 5.

The fragmentation of the neutral excited molecule has been examined briefly on the basis of the isotopic analysis of products formed in the photolysis of $CD_3CH_2CH_2CD_3$ - O_2 mixtures at 1470 Å, 1236 Å, and 1067 Å-1048 Å, and of those formed in the photolysis of C_4D_{10} - H_2S mixtures at 1236 Å. It is concluded that the modes of decomposition of the superexcited molecule are essentially identical to those observed for molecules excited at photon energies below the ionization energy, although the elimination of an H_2 molecule or an alkane may be of lesser importance at the shorter wavelength.

9273. **Ion-molecule reaction in the liquid and solid phase radiolysis of hydrocarbon mixtures,** P. Ausloos, A. A. Scala, and S. G. Lias, *J. Am. Chem. Soc.* **88,** 1583-1584 (1966).

Key words: Hydrocarbons; ion-molecule reactions; radiolysis.

Experimental results are presented which for the first time demonstrate that ion-molecule reactions occur in the liquid and solid phase radiolysis of hydrocarbons and that they can be investigated in a systematic manner.

9274. **The National Bureau of Standards and its contributions to geophysics,** D. Baker, *Trans. Am. Geophys. Union* **17,** No. 4, 563-568 (Dec. 1966).

Key words: Geophysics; gravity; ionosphere; seismology.

Almost from its inception the National Bureau of Standards has made contributions to the field of geophysics. Major contributions are reviewed, including gravity measurements, IGY participation, seismology, and atmospheric and ionospheric investigations.

9275. **Sodium-electron spin-exchange collisions,** L. C. Balling, *Phys. Rev.* **151,** No. 1, 1-6 (Nov. 4, 1966).

Key words: Electron; optical pumping; sodium; spin-exchange.

A spin-exchange optical pumping experiment to study collisions between sodium atoms and free electrons is reported. In this experiment, electrons in a weak magnetic field were polarized by spin-exchange collisions with optically pumped sodium atoms. The sodium-electron collisions were the principal source of the electron resonance linewidth, and they also produced a shift in the electron resonance frequency. The magnitudes of the linewidth and the frequency shift depend upon the scattering amplitude for sodium-electron collisions, the sodium polarization and the sodium atom density. The ratio of the frequency shift to the linewidth was 0.03. The sodium polarization was approximately 30%. The electron resonance frequency was lower when the sodium polarization was positive. The measurements of the electron linewidth and the frequency shift agree with theoretical values of the linewidth and frequency shift obtained from the sodium-electron scattering phase shifts which have been recently calculated by Garrett.

9276. **The absorption spectrum of RbD. Vibrational numbering of the $A^1\Sigma$ state of RbH,** I. R. Bartky, *J. Mol. Spectry.* **21,** No. 1, 1-3 (Sept. 1966).

Key words: Absorption spectroscopy; alkali metal hydrides; hydrides; isotope relations; molecular constants.

RbD has been observed in absorption from 5200-5400 Å. Of the several bands observed in this region, two have been analyzed in detail. The RbD spectrum correlates with the RbH spectrum only if the vibrational numbering of the $A^1\Sigma$ state of RbH is increased by 3. Revised molecular constants for RbH are given.

9277. **The absorption spectrum of cesium deuteride. The $A^1\Sigma$ state of CsH,** I. R. Bartky, *J. Mol. Spectry.* **21,** No. 1, 25-28 (Sept. 1966).

Key words: Absorption spectroscopy; alkali metal hydrides; hydrides; isotope relations; molecular constants.

An analysis of the visible absorption spectrum of CsD has shown that the vibrational numbering of the $A^1\Sigma$ state of CsH must be increased by 3. From this and previous reassignments of the $A^1\Sigma$ states of KH and RbH, it is now possible to exhibit the trends of the vibrational and rotational constants for the alkali metal hydrides.

9278. **The $A^1\Sigma$ - $X^1\Sigma$ transition of ^{39}KH and ^{39}KD. Vibration numbering and molecular constants,** I. R. Bartky, *J. Mol. Spectry.* **20,** No. 4, 299-311 (Aug. 1966).

Key words: Absorption spectroscopy; alkali metal hydrides; hydrides; isotope relations; molecular constants.

The absorption spectrum of KD has been observed in the 5100-5200 Å region. An analysis of the spectrum in this region has shown that the previous assignments of the KD and KH spectra are in error. The v′-numbering of KD must be increased by 3, and the J-numbering of the P and R branches must be decreased by 1; the v′-numbering of KH must be increased by 2. Re-analysis of the existing data on KH and KD has given a consistent set of vibrational and rotational constants for the states of these molecules.

9279. **An improved design for vacuum ultraviolet resonance lamps,** A. M. Bass, *Appl. Opt.* **5,** No. 12, 1967 (Dec. 1966).

Key words: Electric discharge; resonance lamp; vacuum ultraviolet; window seal.

A method is described for sealing lithium fluoride windows to resonance lamp discharge tubes so as to avoid damage to the seal by action of the discharge.

9280. **Message from outgoing editor,** R. W. Beatty, *IEEE Trans. Microwave Theory Tech.* **MTT-14,** No. 4, 170 (Apr. 1966).

Key words: Abstracts; editing; journals; publishing; redacting.

The outgoing editor notes the growth of the Transactions and the addition of the microwave abstracts. He calls attention to the formation of a panel of editors and their activities. He observes the intricate process of publishing a Transactions and notes that although it does not reach the readers promptly, steps are being considered which will speed up the process.

Recognition is given to the contributions of others in getting out the Transactions and confidence is expressed in the new editor and in the future of the Transactions.

9281. **Mass-spectrometric study of photoionization IV. Ethylene and 1,2-dideuteroethylene,** R. Botter, V. H. Dibeler, J. A. Walker, and H. M. Rosenstock, *J. Chem. Phys.* **45,** No. 4, 1298-1301 (Aug. 15, 1966).

Key words: Autoionization; 1,2-dideuteroethylene; ethylene; mass spectra; photoionization; Rydberg; threshold energies.

Photoionization efficiency curves for ions of the molecule and of selected fragments of C_2H_4 and CHDCHD are reported for the wavelength region from onset of ionization to 600Å. The minimum threshold of ionization is 10.50 eV for both molecules. In addition, certain features of the ion yield curves are discussed and identified as resulting from vibrationally excited states or from autoionization from Rydberg levels leading to electronically excited states. Threshold measurements of the acetylene ions permit calculation of heats of dissociation and indicate that the $C_2H_2^+$ ion is formed without excess activation energy. Of the vinyl ions, the threshold for the $C_2H_3^+$ ion is the most clearly defined and leads to a C_2H_3-H bond dissociation energy of 100 kcal/mol (418 kJ/mol).

9282. **Exchange and direct second virial coefficients for hard spheres,** M. E. Boyd, S. Y. Larsen, and J. E. Kilpatrick, *J. Chem. Phys.* **45,** No. 2, 499-508 (July 15, 1966).

Key words: Hard spheres; quantum statistics; quantum virial coefficient; second virial coefficient.

We have separated the quantum mechanical second virial coefficient for hard spheres, B, into two terms. The first represents the contribution of a Boltzmann gas, and the second is an exchange term embodying the effects of quantum statistics. Numerical computation of B to a high precision then allows us to analyze the temperature dependence of the exchange term - which is found to decrease exponentially with temperature - and to determine the asymptotic expansion of the Boltzmann term at high temperatures.

9283. **The National Standard Reference Data System,** E. L. Brady, *J. Chem. Doc.* **7,** No. 1, 6-9 (Feb. 1967).

Key words: Future plans; National Standard Reference Data System; objectives; operation; status.

The National Standard Reference Data System is a government-wide effort to give to the technical community of the United States optimum access to quantitative data on the physical and chemical properties of substances and their interactions, critically evaluated and compiled for convenience. The general functions of the System are to coordinate and integrate existing data evaluation and compilation activities into a systematic, comprehensive program, supplementing and expanding technical coverage when necessary, establishing and maintaining standards for the output of the participating groups, and providing mechanisms for the dissemination of the output as required. This program was established as a Federal policy in 1963 upon the recommendation of the Federal Council for Science and Technology. The National Bureau of Standards of the Department of Commerce has accepted responsibility for administering the effort. The plan of operation and the general status of activities initiated by the National Bureau of Standards will be described.

9284. Unassigned.

9285. **Photodetachment cross section, electron affinity, and structure of the negative hydroxyl ion,** L. M. Branscomb, *Phys. Rev.* **148,** No. 1, 11-18 (Aug. 5, 1966).

Key words: Cross section; electron affinity; molecular structure; negative hydroxyl ion; OD^- ions; OH^- ions; photodetachment.

Experimental data on the cross section for photodetachment of OH^- and OD^- ions are given and used to argue that $r_e(OH^-) = r_e(OH) \pm 0.0002$Å, that $\omega_e(OH^-) = 3700 \pm 560$ cm^{-1} and that the OH electron affinity E. A. (OH) $= 1.83 \pm 0.04$ eV. Thus, the structure of OH^- and OH are remarkably similar, which is consistent with the theoretical predictions of Cade.

9286. **Flash photolysis of methane in the vacuum ultraviolet. I. End-product analysis,** W. Braun, K. H. Welge, and J. R. McNesby, *J. Chem. Phys.* **45,** No. 7, 2650-2656 (Oct. 1, 1966).

Key words: Acetylene; combination; ethane; ethylene; flash photolysis; gas phase; hydrogen; hydrogen deuteride; insertion; methane; methyne; rate; vacuum ultraviolet.

Methane and mixtures of methane and methane-d_4 have been subjected to flash photolysis in the vacuum ultraviolet. Ethylene is the major hydrocarbon product. Isotopic distributions of the hydrogen, ethane and ethylene fractions as well as complete product analysis suggest that CH plays a dominant role in the photolysis. The CH is formed either by direct dissociation of excited methane or secondary flash photolysis of CH_2 in the flash. On the basis that acetylene is formed with unit efficiency by association of CH, and ethylene is formed by reaction of CH with methane, the collision yield of the latter reaction is about 1/82.

9287. **A vacuum ultraviolet flash photolysis apparatus,** W. Braun, A. M. Bass, and A. E. Ledford, Jr., *Appl. Opt.* **6,** No. 1, 47-49 (Jan. 1967).

Key words: Apparatus description; flash photolysis; vacuum ultraviolet.

An improved apparatus for performing vacuum ultraviolet flash photolysis-kinetic spectroscopy has been constructed. The device consists of a compact coaxial arrangement of six capacitors and six electrode pairs, symmetrically placed about a hexagonal reaction vessel of large aperture. The reaction vessel contains LiF windows to transmit far ultraviolet radiation. The six pairs of electrodes and six capacitors are connected separately and are synchronously fired, uniformly illuminating the reaction cell. The photolytic light pulse duration is about 5 μ sec. More than 10^{18} quanta enter the reaction vessel in the spectral region between 1050 Å and 1600 Å. The essential operating features of the apparatus are described.

9288. **Chemiluminescence of CH in the $O+C_2H_2$ reaction: Rotational relaxation and quenching,** W. Brennen and T. Carrington, *J. Chem. Phys.* **46,** No. 1, 7-18 (Jan. 1, 1967).

Key words: Acetylene; CH; chemiluminescence; cross section; emission spectrum; energy transfer; experimental; gas; oxygen atom; oxidation; population distribution; rotation.

Rotational distributions of $CH(A^2\Delta, v=0)$ were measured at pressures from 0.1 to 8.5 torr in the $O+C_2H_2$ reaction in the presence of large excess of N_2, Ar, or He. The reaction $N+NO \rightarrow N_2+O$ was used to produce O without O_2. Under all conditions the distributions are found to be a superposition of two Boltzmann distributions, one at 1200-1400 °K characteristic of the process leading to the formation of excited $CH(A^2\Delta)$, and one which stays close to the temperature of the reactor. Interpreting the fraction of molecules in this low temperature distribution as a measure of the extent of relaxation of the initial rotational distribution of excited CH, average relaxation rate constants are derived. With the collision partners mentioned above, 10 to 30 collisions are required for relaxation. A 14-level phenomenological model including only transitions between neighboring rotational levels $(K \rightarrow K \pm 1)$ fits the experimental distributions well at all pressures studied if the downward rate constants, $k_{K-1,K}$ are approximately proportional to exp $(-2BK/kT)$, where $B=14.6$ cm^{-1} is the rotational constant for $CH(A^2\Delta, v=0)$ and $T=360$ °K. Other models are discussed. Rotational and vibrational distributions for $CD(A^2\Delta)$ are also described. Quenching of the $CH(A \rightarrow X)$emission by added oxygen was studied quantitatively and the results are consistent with a mechanism in which not $CH(A^2\Delta)$ but a precursor to its formation is removed by O_2. In the absence of O_2 the lifetime of the precursor is determined primarily by the atomic oxygen concentration.

When an electrical discharge through O_2 is used as the source of oxygen atoms for reaction with acetylene, the rotational distribution of $CH(A^2\Delta)$ and its pressure dependence is quite different from that described above. When acetylene reacts with the products of a discharge through CO_2 with excess CO_2 as heat bath, the rotational distribution of $CH(A^2\Delta)$ has a Boltzmann form at all pressures, with only the rotational temperature depending on pressure and approaching the gas kinetic temperature at high pressure.

9289. **Spin-relaxation effects on the EPR spectrum of gaseous *s*-state atoms,** R. L. Brown and W. Brennen, *J. Chem. Phys.* **46,** No. 1, 385-386 (Jan. 1, 1967).

Key words: Electron paramagnetic resonance; flow system kinetics; hydrogen atoms; nitrogen atoms; spin exchange cross sections; spin relaxation time.

Experimental evidence has been obtained which indicates that N atoms produced in a flow system by a microwave discharge through purified N_2 had a "spin-lattice" relaxation time of the order of 25 milliseconds. The residence time of the atoms in the EPR magnet was comparable to this. As a result, the atoms (which were generated outside of the magnet) arrived at the microwave cavity before reaching their equilibrium magnetization. The EPR absorption intensity was abnormally small since the population difference between the Zeeman levels was smaller than at equilibrium.

9290. Unassigned.

9291. **Influence of paramagnetic resonance on the static susceptibility. The lattice-bath relaxation time of neodymium ethylsulfate,** G. A. Candela and R. E. Mundy, *J. Chem. Phys.* **46,** No. 1, 47-54 (Jan. 1, 1967).

Key words: Electron static susceptibility; lattice-bath; neodymium ethylsulfate; relaxation time; spin saturation.

The spin-lattice-bath relaxation process of neodymium ethylsulfate was investigated by measuring simultaneously the change in the static susceptibility and the microwave power absorbed at electron spin resonance. This technique can be used at constant temperature to distinguish the spin-lattice process from the lattice-bath process. The relaxation time of neodymium ethylsulfate was studied at a microwave frequency of 14.5 G Hz as a function of temperature, helium exchange gas pressure, microwave power absorbed, two crystal orientations, and crystal size. At this microwave frequency the energy transfer from the lattice to the bath appears to be the rate determining process. The dominant lattice-bath relaxation time, τ_p, is inversely proportional to the square of the bath temperature $\tau_p T^2 = 0.20$ sec °K^2 but is apparently independent of the crystal size, the helium exchange gas pressure, and crystal orientation. The experimental data are in essential agreement with the data obtained by other researchers using different methods.

9292. **Studies of some exploding wire light sources,** E. C. Cassidy and S. Abramowitz, *J. Soc. Motion Picture Television Eng.* **75,** No. 8, 735-737 (Aug. 1966).

Key words: Aluminum; AlH; AlO; atomic spectra; electrical discharges; exploding wires; light sources; time-resolved spectroscopy; titanium; TiO.

Continuous and time-resolved measurements of the spectral distribution of light emitted by various exploding wire systems have been obtained by use of a high-speed drum camera and a rotating shutter, respectively. Results from experiments with several systems show the effects of environment, pressure, energy, and wire material on the spectrum. Various intermediate species, produced by the explosion, are determined spectroscopically.

9293. **Interference in the photoionization of molecules,** H. D. Cohen and U. Fano, *Phys. Rev.* **150,** No. 1, 30-33 (Oct. 7, 1966).

Key words: Diatomic molecule; interference; photoionization; ultraviolet.

Atoms of a molecule exposed to far-ultraviolet light may be treated approximately as separate sources of photoelectrons. Interference from these sources modulates the spectrum of photoabsorption in accordance with Samson's observations on N_2 and O_2. A Born approximation calculation for H_2^+ displays details of this effect.

9294. **Vibrational spectrum of $ClNF_2$,** J. J. Comeford, *J. Chem. Phys.* **45,** No. 9, 3463-3465 (Nov. 1, 1966).

Key words: Chlorodifluoramine; infrared spectra; matrix-isolation; spectra; vibrational assignment; vibrational fundamentals.

The infrared spectrum of chlorodifluoramine has been examined for the region of the fundamentals in both the gas-phase and in an argon matrix at 20 °K. The previously unassigned fundamental, ν_6, has been observed, completing the vibrational assignment.

9295. **Classification of the $Y_1^*(1765)$ and $Y_0^*(1520)$ resonances in the 1134 representation of SU(6),** J. J. Coyne, S. Meshkov, and G. B. Yodh, *Phys. Rev. Letters* **17,** No. 12, 666-668 (Sept. 19, 1966).

Key words: Baryon resonances; classification; decay widths; higher symmetry; SU(3); $SU(6)_W$.

The $Y_1^*(1765)$ $5/2^-$ resonance exhibits ratios of meson-baryon (8×8) decay widths to meson-baryon resonance (8×10) decay widths such as to indicate that it can be classified in the 1134 product representation of SU(6). A comparison of the decay modes of the $Y_0^*(1520)$ with those of the $Y_1^*(1765)$ shows that it, too, may be classified in the 1134.

9296. **Static theory of the giant quadrupole resonance in deformed nuclei,** M. Danos, W. Greiner, and B. C. Kohr, *Phys. Rev.* **151,** No. 3, 761-772 (Nov. 18, 1966).

Key words: Deformed nuclei; giant resonance; nuclear hydrodynamics; octupole deformation; photon absorption; quadrupole resonance.

The modes and frequencies of the giant quadrupole resonance of heavy deformed nuclei have been calculated. The quadrupole operator is computed and the absorption cross section is derived. The quadrupole sum rule is discussed and the relevant oscillator strengths have been evaluated for various orientations of the nucleus. The giant quadrupole resonances have energies between 20 and 25 MeV. The total absorption cross section is about 20% of the giant dipole absorption cross section. Of particular interest is the occurrence of the quadrupole mode in a direction of approximately $\theta = 1/4\pi$ from the symmetry axis. This may give information on the details of the nuclear shape.

9297. **Electrodynamic vibration standard with a ceramic moving element,** T. Dimoff, *J. Acoust. Soc. Am.* **40,** No. 3, 671-676 (Sept. 1966).

Key words: Air bearing; ceramic moving element; electrodynamic shaker; piezoelectric accelerometers; reciprocity; secondary standard; vibration standard.

This report describes a new rectilinear vibration exciter specifically developed for accurate calibration of piezoelectric accelerometers. It is an electrodynamic shaker using a permanent magnet with a ceramic moving element guided by an air bearing system. The moving element has a simple cross section and the driving coil is wound directly onto it. Its first axial resonance is near 25,000 Hz. The working range of the shaker extends from 5000 Hz to less than 5 Hz.

The moving element includes a means of mounting an internal accelerometer which can be used as a secondary standard. Alternatively, the moving element - accelerometer assembly can be calibrated by a reciprocity method and used as an absolute standard.

The results of measurements of transverse motion and harmonic distortion are presented as well as an example of pickup calibration.

9298. **A scattering chamber for use with cooled large area lithium-compensated silicon radiation detectors,** W. R. Dodge, J. A. Coleman, and S. R. Domen, *Nucl. Instr. Methods* **42,** No. 2, 181-187 (July 1966).

Key words: Detector telescope; large area detectors; photonuclear physics apparatus; scattering chamber; semiconductor detectors.

A scattering chamber designed to be used with large area lithium-compensated silicon radiation detectors has been constructed. The chamber has provision for cooling a circular array of detectors to 77 °K to achieve short charge collection times and good resolution. The apparatus was designed to be used with the NBS 180-MeV synchrotron in photoproton experiments in the 2 to 35 MeV proton energy interval.

9299. **Measurement of the mean energy required to create an electron-hole pair in silicon between 6 and 77 °K,** W. R. Dodge, S. R. Domen, T. F. Leedy, and D. M. Skopik, *Phys. Rev. Letters* **17,** No. 12, 653-655 (Sept. 19, 1966).

Key words: Energy, required to create an electron-hole pair; low temperature; recombination; Shockley theory of ϵ; silicon radiation detectors; trapping.

Relative values of the mean energy required to create an electron-hole pair with ^{207}Bi conversion electrons between 6 and 77 °K have been measured. The data show that ϵ exhibits no first order variation with temperature from 6 to 77 °K. Previous measurements had yielded values as high as 5.22±.02 eV/electron-hole pair at 20 °K.

9300. **Calculated heats of dilute solid solution among the alkali halides other than cesium salts,** T. B. Douglas, *J. Chem Phys.* **45,** No. 12, 4571-4585 (Dec. 15, 1966).

Key words: Alkali halides; heats of solution; ion substitution; lattice relaxation; polarization energy; shell calculations; solid solutions.

Limiting high-temperature heats (energies) of dilute solid solution are calculated for all 96 cases of one NaCl-type alkali halide (except Cs salts) dissolving in another having a common ion. The direct-summation shell treatment used is based on a slightly modified Born-Mayer potential function and on the polarization energy up to terms square in the ion polarizabilities. Preliminary general expansion of the energy in positive powers (up to cubic) of the lattice-relaxation (ion-displacement) parameters of the first eight shells (98 neighbors) facilitated application to specific cases. In the linear solution for the minimum-potential lattice relaxation, one or two iterations for the first two shells sufficed. The convergence of the energy expansions and the sensitivity of the calculated energies to arbitrary variations in the semi-empirical parameters were extensively investigated. Comparison is made with calorimetric heats of solution in 16 cases, the agreement (averaging ±10 percent) lying within the experimental and computative errors.

9301. **Status of light-element heat-capacity calorimetry at the National Bureau of Standards: A review of the high-temperature thermodynamics of the BeO-H_2O system,** T. B. Douglas, *Proc. 4th Meeting Interagency Chemical Rocket Propulsion Group, Working Group on Thermochemistry, Kennedy Space Flight Center, Florida,* Mar. 16-17, 1966, **I,** No. 108, 27 (Chemistry Propulsion Information Agency, Silver Spring, Md., June 1966).

Key words: Beryllium oxide; calorimetry; chemical propulsion; equilibrium; estimates; thermodynamics.

Heat-capacity calorimetry recently completed and in progress at the National Bureau of Standards is reviewed briefly. After a critical review of the thermodynamic properties of the BeO-H_2O system, it is concluded that the product of the reaction between BeO(c) and H_2O(g) below 1850 °K is probably largely $Be(OH)_2$(g), but that higher hydrates may be sufficiently stable to hold considerable amounts of BeO in the gas phase at much higher temperatures.

9302. **Erratum: Statistical model for the beta zirconium hydrides,** T. B. Douglas, *J. Chem. Phys.* **45,** No. 3, 1080 (Aug. 1, 1966).

Key words: Beta zirconium hydrides; statistical model; zirconium hydrides.

An inadvertent error in sign is corrected in an equation in an article of the author's published earlier in the Journal of Chemical Physics. Only the correct equation, it is added, was used in the computations in the article.

9303. **Survey of infrared measurement techniques and computational methods in radiant heat transfer,** S. T. Dunn, J. C. Richmond, and J. F. Parmer, *J. Spacecraft Rockets* **3,** No. 7, 961-975 (July 1966).

Key words: Computational methods; emissivity; emittance measurements; radiant heat transfer; reflectance measurements; thermal radiation.

This paper is an analysis of 133 replies to a questionnaire sent to all known workers in the field of thermal radiation property measurements and radiant heat transfer computations. The questions were designed to obtain information on the current state of the art in these fields. In addition, the authors have supplemented the information obtained from the questionnaire to give a broad over all picture of the current status and future needs in each area covered. A brief summary of Russian literature in the field of thermal radiation property measurements is also included.

9304. Unassigned.

9305. **A method for calibrating volt boxes, with analysis of volt-box self-heating characteristics,** R. F. Dziuba and T. M. Souders, *IEEE Intern. Conv. Record,* **Part 10,** p. 17 (Mar. 21-25, 1966).

Key words: Calibration; errors; heating; voltage divider; volt-box.

A modification of the Julie ratiometric method for calibrating volt boxes has been under study at NBS to evaluate its performance as a useful calibration technique. The modification features speed of operation, high accuracy and rated voltage measurements. Evaluation of the method accelerated an investigation of self-heating errors of volt boxes that was in progress. The results of this study together with an analysis of self-heating curves are included.

9306. **Additional thoughts on precision calibration of accelerometers,** S. Edelman, *Test Engineering and Management* **XVI,** No. 5, p. 17 (Nov. 1966).

Key words: Accelerometer; calibration; comparison calibration; frequency range; shaker; vibration.

This consists of a number of comments on an article by W. P. Kistler. It shows why reliable calibration of vibration measuring instruments requires careful measurements over the entire frequency range of interest.

9307. **Anniversaries in 1966-67 of interest to statisticians Part I: Introduction and summary,** C. Eisenhart, *Am. Stat.* **21,** No. 2, 32-34 (Apr. 1967).

Key words: Anniversaries; statisticians, 1966, 1967.

Brief descriptions, with minimal documentation, of twenty-six anniversaries in 1966 and 1967 of potential interest to statisticians.

9308. **A study of the angular and energy distributions of radiation at small distances from a point source of gamma rays or neutrons,** C. Eisenhauer, *Nucl. Sci. Eng.* **27,** No. 2, 240-251 (Feb. 1967).

Key words: Air-scatter; angular distribution; energy spectrum; gamma rays; neutrons; point source; shielding; single scatter.

The theoretical expression for the singly scattered angular and energy flux of radiation from a point source is studied in the limit of very small source-detector separation distances, $(\mu_0 r \ll 1)$. It is shown that both the angular and energy distributions are related in a simple way to the scattering kernel. Examples are given for gamma and neutron point sources in air. The applicability of the distributions at separation distances of the order of a mean free path $(\mu_0 r \approx 1)$ is discussed.

9309. **Effects of errors in the chemical literature on the compilation of critically evaluated data,** W. H. Evans, *J. Chem. Doc.* **6,** No. 3, 135-136 (Aug. 1966).

Key words: Chemical literature; critical data; data evaluation; errors.

The various types of errors in data presented in the chemical literature and their effects on the critical evolution of the data are discussed. The relatively unsatisfactory state of errata is mentioned from the point of bringing the correction and the original publication together.

9310. **Some approximations to the Planck function in the intermediate region with applications in optical pyrometry,** D. E. Erminy, *Appl. Opt.* **6,** No. 1, 107-117 (Jan. 1967).

Key words: Brightness temperature; color temperature; effective wavelength; infrared and far infrared optical pyrometry; Planck equation; Rayleigh-Jeans equation; spectral radiance; Wien equation.

For many applications, a simple approximate equation for blackbody radiation can be more useful than is the Planck blackbody equation. An intermediate region exists where both the Rayleigh-Jeans equation and the Wien equation for blackbody radiation are inaccurate approximations to the Planck equation. Several approximate equations of simple mathematical form have been obtained which are more accurate in this intermediate region. These equations are applied to optical pyrometry to obtain formulae for brightness temperature and color temperature that can be used in the intermediate region.

9311. **Radiation absorption between the ultraviolet and x-ray bands,** U. Fano, *Science* **153,** No. 3735, 522-525 (July 29, 1966).

Key words: Absorption; radiation; spectroscopy; ultraviolet; x-rays.

A brief report is presented concerning the recent initial exploration of photoabsorption in a previously unmapped portion of the spectrum.

9312. **Approximate normal emissivity spectra in the infrared at elevated temperatures of single-crystal and polycrystalline calcium fluoride,** W. B. Fussell and J. C. Geist, *Appl. Opt.* **6,** No. 1, 119-124 (Jan. 1967).

Key words: Calcium fluoride; elevated-temperature emissivity; infrared absorption coefficients; infrared emissivity; polycrystalline CaF_2; single-crystal CaF_2.

A single-beam infrared spectroradiometric system has been used to measure the normal spectral emissivity of specimens of single-crystal and polycrystalline calcium fluoride in the infrared at elevated temperatures. The wavelength range was 2 to 12 microns and data were taken at sample temperatures of 500 and 600 °C. Room temperature data on the index of refraction of single-crystal calcium fluoride, and its rate of change with temperature, were extrapolated to 500 and 600 °C, and the normal spectral reflectivities were computed from the extrapolated indices at these temperatures. The computed reflectivities were then used to extract normal spectral absorption coefficients from the emissivity data. It was possible to compute absorption coefficients with reasonable accuracy at wavelengths of 6, 8, and 10 microns; the smallest estimated error was about 2% at 8 microns. The absorption coefficients increased markedly with temperature at these three wavelengths. The absorption coefficients of the polycrystalline material were consistently higher than the corresponding values for the single-crystal calcium fluoride. It was found that the spectral absorption coefficients at 8 and 10 microns varied approximately as the 2.1 and 1.6 power of the absolute temperature, respectively, between room temperature and 600 °C. These exponents lie within the range predicted by theory.

9313. **Definition of temperature in the kinetic theory of dense gases,** L. S. Garcia-Colin and M. S. Green, *Phys. Rev.* **150,** No. 1, 153-158 (Oct. 7, 1966).

Key words: Bulk viscosity; macroscopic equations of motion; macroscopic variable; non-equilibrium kinetic energy; temperature; total energy.

The question of the appropriate definition of temperature in the kinetic theory of dense gases is discussed. An apparent contradiction in the value of the bulk viscosity between two methods of making the transition from the kinetic to the hydrodynamic stage is resolved. It is shown that the definitions of temperature through the kinetic energy and through the total energy are equivalent. The general question of the appropriate choice of macroscopic variables in non-equilibrium statistical mechanics is discussed.

9314. **New method and problems in combinatorial optimization,** A. J. Goldman, *Washington Oper. Res. Council Newsletter* **5,** No. 8, 4-8 (Apr. 1966).

Key words: Algorithms; combinatorics; mathematics; matroids; networks; operations research; optimization.

This paper describes recent progress at the National Bureau of Standards in the field of combinatorial optimization.

9315. **A new contribution – NBS and engineering standards,** G. S. Gordon, *Safety Standards* **XVI,** No. 1, 3-4 (Jan.-Feb. 1967).

Key words: Engineering standards; international and national standards activities; OESLA; standards-making bodies.

The need for greater participation by NBS in helping to strengthen the nation's standards program was called for in the recent report of the LaQue Committee. The Office of Engineering Standards Liaison and Analysis *(OESLA)* has been established as the focal point at NBS for making available the technical resources of Bureau personnel *to assist* the federal, state and local governments, private engineering *standards-making bodies* and manufacturers in developing adequate representation of industrial, consumer and general public interests *in national and international standards activities.*

9316. **Air bath thermostat for use with absorption spectrophotometer,** J. H. Gould, *Rev. Sci. Instr.* **37,** No. 9, 1229-1231 (Sept. 1966).

Key words: Spectrophotometry; thermostat; ultraviolet-visible; – 150 to +60 °C.

An automatically controlled absorption cell thermostat with a useful range of from – 150 to +60 °C is described and has been successfully used with a commercial spectrophotometer. This apparatus accepts ordinary cylindrical absorption cells to 5 cm in length.

9317. **Note on normal subgroups of the modular group,** L. Greenberg, *Proc. Am. Math. Soc.* **17,** No. 5, 1195-1198 (Oct. 1966).

Key words: Factor set; group extension; level; modular group; parabolic class number; quotient surface; split extension.

Let N be a normal subgroup of the modular group Γ, of index μ and parabolic class number t. It is shown that $\mu \leqslant 6t^4$. It follows immediately from this that there are only a finite number of normal subgroups with given parabolic class number. This is in sharp contrast to the case of non-normal subgroups. For it is known that for any integer $t \geqslant 1$, there are infinitely many subgroups of finite index with t parabolic classes. It is also shown that if p is a prime such that $p \equiv -1 \pmod 3$, then there are no normal subgroups with p parabolic classes.

9318. **A new near-zone electric field-strength meter,** F. M. Greene, (Proc. 8th IEEE Symp., Electromagnetic Compatibility, San Francisco, Calif., July 11-13, 1966), *Symposium Digest, New Ideas for Electromagnetic Compatibility, 1966.*

Key words: Device; field; hazards; line; meter; telemetry.

The National Bureau of Standards has recently completed the development of prototype instrumentation for measuring the electric-field components of complex, high-level, near-zone electromagnetic fields from 0.1 to 1000 volts per meter, at frequencies from 150 kHz to 30 MHz with a present uncertainty of less than ±2 dB. The successful design of the NBS meters is based on the use of a novel form of telemetry, employing a completely non-metallic electrical transmission line, which apparently has not been fully exploited heretofore. This avoids the perturbing effects on the field being measured, usually caused by field-strength meters employing metallic RF transmission lines.

9319. **Baffled piston radiator: expansion of potential in far, paraxial field,** M. Greenspan, *J. Acoust. Soc. Am.* **40,** No. 1, 251-252 (July 1966).

Key words: Acoustics; diffraction, potential; piston radiator; potential diffraction; radiator, piston; sound.

The potential of a circular source, having radially symmetrical but otherwise arbitrary distribution, $v(r_o)$ of velocity over its face, is expanded as $\phi=z^{-1}e^{-ikz}(a_o+a_1a^{-1}+. \; . \; .)$[Cylindrical coordinates (r,θ,z); center of source at $r=z=0$]. We find a_o to depend only on the total volume velocity at the source. If $v(r_o)$ is known, all a_n can be calculated; if it is unknown, limits on a_n can be set.

9320. **Growth of calcite crystals,** P. M. Gruzensky, (Proc. Intern. Conf. Crystal Growth, Boston, Mass., June 20-24, 1966), *Crystal Growth, a Suppl. to J. Phys. Chem. Solids* **D3,** 365-367 (Pergamon Press Inc., New York, N.Y., 1967).

Key words: Calcite; crystal growth; crystals; vapor phase diffusion.

Renewed interest in the growth of synthetic calcite crystals has been stimulated by the possible use of calcite as a host crystal for maser materials. A crystal growth method is described in which $(NH_4)_2CO_3$, by vapor phase diffusion, is slowly brought into contact with a solution containing 2 wt percent $CaCl_2$ and 20 wt percent NH_4Cl. Transparent rhombs are obtained with edge dimensions of 3-4 mm, which are verified to be calcite by x-ray diffraction measurements.

9321. **A modified Monte-Carlo quadrature,** S. Haber, *Math. Compt.* **20,** No. 95, 361-368 (July 1966).

Key words: Analysis; integration; mathematics; Monte-Carlo; multiple integration; numerical analysis; numerical integration; quadrature.

A modification of Simple Monte-Carlo quadrature is proposed, which uses very simple forms of stratified sampling and of the "method of antithetic variates." The new procedure is fully automatic, requiring no preliminary analysis of the integrand, and converges somewhat faster than Simple Monte-Carlo. Results of experimental calculations are presented.

9322. **Abstraction of hydrogen atoms from isobutane-d_9 by methylene,** M. L. Halberstadt and J. R. McNesby, *J. Chem. Phys.* **45,** No. 5, 1666-1669 (Sept. 1, 1966).

Key words: Abstraction; isobutane-d_9; ketene; methylene; photolysis.

The photolysis of ketene at 3130 Å in the presence of isobutane-d_9 was carried out at 320 °C in order to determine the mechanism of methyl radical formation. The two possibilities considered are:

Mechanism I – insertion followed by internal relaxation and finally expulsion of a methyl radical.
Mechanism II – direct abstraction.

Mechanism II was found to be the only detectable mode of methyl radical formation. The effect of pressure on the isotopic methane distribution was studied and an attempt is made to explain the effect in terms of a DeMore-Benson process.

9323. **Two quantum photoionization of Cs and I^-,** J. L. Hall, *J. Quantum Electron* **QE-2,** No. 4, xxi (April 1966); *IEEE J. Quantum Electron* **QE-2,** No. 9, 361-363 (Sept. 1966).

Key words: Atomic calculations; nonlinear optical phenomenon; two-photon ionization.

Brief review of a recent experiment which measured the photodetachment probability for I^- ions due to simultaneous absorption of two ruby quanta.

9324. **Unassigned.**

9325. **A nonmagnetic laboratory for the National Bureau of Standards,** F. K. Harris, *IEEE Spectrum* **3,** No. 11, 85-87 (Nov. 1966).

Key words: Absolute ampere determination; calculable inductor; current balance; national electrical units; nonmagnetic facility: Pellat dynamometer: proton precession frequency.

Plans are discussed for a nonmagnetic laboratory to be built on the Gaithersburg campus of the National Bureau of Standards for absolute electrical measurements and other purposes. The operation of the NBS current balances and the proton gyromagnetic ratio apparatus is briefly reviewed, and a short history of the national electrical units since the creation of the Bureau is included.

9326. **Spectral radiance of a low current graphite arc,** A. T. Hattenburg, *Appl. Opt.* **6,** No. 1, 95-100 (Jan. 1967).

Key words: Arc; blackbody; graphite; spectral radiance; spectroradiometer; temperature.

The spectral radiance of the anode of a low-current graphite arc has been determined throughout most of the 850 to 210 nm region, utilizing a recently developed high-accuracy spectroradiometer. The estimated standard deviation uncertainty varies from about 1.5% at the longer wavelengths to about 5% at the shorter. Results are given at twenty wavelength points in the region, and also as a continuous function of wavelength throughout most of the region, excluding some areas of high molecular band radiation originating in the arc stream.

9327. **The "volt standard" moves to Gaithersburg, Maryland,** W. J. Hamer, *J. Wash. Acad. Sci.* **56,** 101-108 (May 1966).

Key words: Electromotive force; standard cell facilities; standard cell transfer; standard cells; volt standard.

A description is given of the transfer of the nation's "volt standard" from its present location in Washington, D.C., to its new location on a site near Gaithersburg, Md. Factors involved in transfer are discussed and a brief description is given of new standard cell facilities in the new laboratory at Gaithersburg.

9328. **Mass-spectrometric study of the rate of the reaction CO + OH,** J. T. Herron, *J. Chem. Phys.* **45,** No. 5, 1854-1855 (Sept. 1, 1966).

Key words: Activation-energy; atom-transfer reaction; carbon dioxide, carbon monoxide; gas phase; hydrogen atom; hydroxyl-radical; rate constant.

The rate constant of the reaction $CO + OH \rightarrow CO_2 + H$ has been directly measured at 300 °K to be 5.4±2.0 (estimated uncertainty) x 10^{10} cm^3 mole^{-1} sec^{-1}. This value combined with published high temperature rate data leads to $k = 9.2 \times 10^{11} \exp(-1000/RT)$.

9329. **Mass spectrometric study of the rates of the reactions of nitrogen atoms with olefins,** J. T. Herron, *J. Phys. Chem.* **70,** No. 9, 2803-2807 (Sept. 1966).

Key words: Atoms; mass; mechanisms; nitrogen; olefins; rates: spectrometry.

A mass spectrometric study has been made of the rates of the reactions of nitrogen atoms with a series of olefins. At 340 °K the rates are: C_2H_4, $k \sim 1.0 \pm 0.5$; C_3H_6, $k = 1.9 \pm 0.6$; C_4H_8-1, $k = 2.0 \pm 0.4$; $t-C_4H_8-2$; $k = 1.7 \pm 0.4$; $iso-C_4H_8$, $k = 4.2 \pm 1.0$; $C_2(CH_3)_4$, $k = 2.4 \pm 0.6$; $C_4H_6-1,3$, $k = 3.5 \pm 1.0$; all x 10^{10} cm^3 mol^{-1} sec^{-1}.

9330. **The forbidden $I^1\Sigma^- - X^1\Sigma^+$ absorption bands of carbon monoxide,** G. Herzberg, J. D. Simmons, A. M. Bass, and S. G. Tilford, *Can. J. Phys.* **44,** 3039-3045 (1966).

Key words: Absorption; carbon monoxide; forbidden transition; high resolution; spectrum; vacuum ultraviolet.

The forbidden $I^1\Sigma^- - X^1\Sigma^+$ transition of CO has been observed at high resolution in the vacuum ultraviolet region. Eight bands have been analyzed to determine rotational and vibrational constants for the $I^1\Sigma^-$ state. The bands consist of a single Q-branch which gains intensity through a rotational mixing of the $I^1\Sigma^-$ and $A^1\Pi$ states. The local perturbations between the I and A states are summarized and discussed. Also an apparent "vibrational" perturbation in the v=4 and 5 energy levels of the I state is described. Indirect evidence suggests the perturbing state is a $^3\Pi$.

9331. **An ultrasonic pressure gage,** P. L. M. Heydemann, (Proc. ASME Winter Meeting, New York, N.Y., Nov. 27-Dec. 1, 1966), *Am. Soc. Mech. Eng. Publ.* No. 66-WA/PT-5 (1967); *J. Basic Eng.* **89,** No. 3, 551-553 (Sept. 1967).

Key words: Delay line; frequency stability; gage; high pressure; self-excited pulse repetition; temperature compensation; ultrasonics; velocity of sound.

The transit time of short ultrasonic pulses in solid rods is used to measure pressures throughout the fluid range. Self-excited regenerating circuits are used. Measurements to 3500 bar with an uncertainty of .3 bar and to 20 kbar with an uncertainty of 2 bar are reported. Further improvements, temperature compensation and stability are discussed.

9332. **Higher symmetries and the 2^+ mesons,** D. Horn, J. J. Coyne, S. Meshkov, and J. C. Carter, *Phys. Rev.* **147,** No. 4, 980-984 (July 29, 1966).

Key words: Higher symmetry scheme; λ quark content; nonet of 2^{++} mesons; Schwinger mass formula; $SU(6)_W$; 405 representation.

The two-body decays of the recently completed nonet of $J^{PC} = 2^{++}$ mesons offer the tempting possibility of delineating in which bigger multiplet of some particular higher symmetry scheme they might be embedded. In this paper, these decays are calculated according to $SU(6)_W$. In such an approach the mesons may be accommodated in either the 189 or 405 representations of SU(6). We show that using only the two-body decay modes of the nonet of spin 2 mesons, one cannot in principle determine whether thay belong in a 189 or 405 representation. This impasse may be broken by ordering states by their λ quark content in which case 189 is eliminated from consideration. In the process, we find that the Schwinger mass formula, which is not satisfied by the experimental masses, should not properly be used for the 405, but should be replaced by a similar relation which is extremely well satisfied.

9333. **A high directivity, broadband coaxial coupler,** P. A. Hudson, *IEEE Trans. Microwave Theory Tech.* **MTT-14,** No. 6, 293-294 (June 1966).

Key words: Coaxial; coupler; directional; reflectometer; RF power.

A new 4-port coaxial directional coupler having high directivity (>50 dB) over relatively broad frequency bands has been designed and constructed. The coupler is the $\lambda/4$ type cut for 1150 MHz and is useful in the frequency bands 700 to 1500 MHz and 3000 to 4000 MHz. Precision connectors (14 mm) are used on all ports and the VSWR of both primary and secondary lines is less than 1.01.

A brief description is given of the performance characteristics of the coupler when used as the equivalent of a matched generator in intercomparing RF power meters.

9334. **Cerous magnesium nitrate: a magnetic temperature scale 0.002-2 °K,** R. P. Hudson and R. S. Kaeser, *Physics* **3,** No. 2, 95-113 (Feb. 1967).

Key words: Cerous magnesium nitrate; low temperature scale; magnetic thermometer.

Isentropic demagnetizations from known starting conditions yielded a determination of the entropy-magnetic susceptibility, or S-χ, relation for single-crystal spheroids of the paramagnetic salt cerous magnesium nitrate, CMN. Enthalpy differences, ΔQ, between the low temperature end-points thus reached and a (arbitrary) reference temperature near 1 °K [determined by gamma ray heating] yielded a corresponding Q-S curve, whence one obtained S-T and χ-T, T being the thermodynamic temperature. The salt exhibits a broad maximum in χ centered on S/R=0.32, for which region the absolute temperature is determined to be 0.001_5 °K. Our results disagree significantly with those of other workers (even S-χ, which is not subject to large experimental error) save for the observation that CMN obeys the Curie law at least down to 0.006 °K.

At high temperatures (T>0.006 °K), all specimens show a heat capacity $C/R=bT^{-2}$ with $b=5.76 \times 10^{-6}$. Superimposed upon this is a small "anomaly" first appearing at approximately 0.015 °K and reaching a maximum near 0.025 °K. The attribution of such an effect to small concentrations of magnetic impurities cannot be reconciled with the results of chemical analysis. Other evidence, moreover, supports the idea of a nonmagnetic origin for this anomaly.

9335. **Production and reaction of atomic fluorine in solids. Vibrational and electronic spectra of the free radical HNF,** M. E. Jacox and D. E. Milligan, *J. Chem. Phys.* **46,** No. 1, 184-191 (Jan. 1, 1967).

Key words: F atom reactions; force constants; HNF; HNF_2; infrared spectrum; matrix isolation; NF; NF_2; thermodynamic properties; visible-ultraviolet spectrum.

The species $H^{14}NF$, $H^{15}NF$, and $D^{14}NF$ have been produced in an argon matrix at 14 °K by the reaction of photolytically produced atomic fluorine with NH. Sufficient concentrations of these species have been obtained for direct detection of two vibrational fundamentals, appearing at 1000 and 1432 cm^{-1} for $H^{14}NF$, as well as of an electronic transition between 3900 and 5000 Å involving a progression in the upper state bending frequency. Force constants and thermodynamic properties have been derived for HNF. Other species observed in these experiments include NF, NF_2, and HNF_2. Evidence is presented indicating that the hydrogen atom can be abstracted from HN_3 by atomic fluorine.

9336. **Physiological optics at the National Bureau of Standards,** D. B. Judd, *Appl. Opt.* **6,** No. 1, 13-26 (Jan. 1967).

Key words: Color; gloss; light; perception of color; photometry; physiological optics; psychophysics; scaling of color.

Published work in physiological optics at the National Bureau of Standards is summarized under the headings: evaluation of light-dark patterns, light measurement, color measurement, color differences, and color perception. The bearing of this work on standard methods of the American Society of Testing and Materials, of the Illuminating Engineering Society, and of the American Standards Association, and on recommendations of the International Commission on Illumination is indicated. The purposes and methods of current work are briefly described.

9337. **Vacuum ultraviolet spectrum of neutral silicon,** V. Kaufman, L. J. Radziemski, Jr., and K. L. Andrew, *J. Opt. Soc. Am.* **56,** No. 7, 911-915 (July 1966).

Key words: Atomic spectrum of silicon; carbon spectra; electrodeless discharge; germanium spectra; nitrogen spectra; silicon I; silicon spectra; vacuum ultraviolet standards.

Measurements have been made on about 200 Si I lines in the region 1548 to 2100 Å excited by a low pressure source, resulting in wavelength values with uncertainties, in general, of less than 0.0015 Å. Some of the vacuum ultraviolet wavelengths had been calculated by Radziemski and Andrew (*J. Opt. Soc. Am.* **55,** 474 (1965), and a comparison of 75 measured and calculated values shows that they agree on the average to 0.0007 Å. A plot of the differences shows the scatter to be much greater than any systematic difference. This indicates that the calculated wavelengths are compatible with the set of Ge I lines used as standards in measuring the Si I lines. The new data have also led to an extension and slight revision of the odd level analysis. New measurements on other Ge I lines and strong lines in the spectra of Ge II, Si II, N I, and C I are also reported. These lines should be useful as auxiliary standards in this spectral region. All of the spectrograms were taken in the first order of a 10.7-meter Eagle vacuum spectrograph with a reciprocal dispersion of 0.78 Å/mm. The source was an electrodeless discharge lamp containing $SiCl_4$ and $GeCl_4$ vapor with argon or helium carrier gas at a total pressure no greater than 0.5 torr.

9338. **Measurement and calculation of Cu II, Ge II, Si II, and C I vacuum-ultraviolet lines,** V. Kaufman and J. F. Ward, *J. Opt. Soc. Am.* **56,** No. 11, 1591-1597 (Nov. 1966).

Key words: Carbon; copper; germanium; Ritz; silicon; spectrum; standards; ultraviolet; vacuum; wavelengths.

The discharge in a water-cooled copper hollow-cathode containing germanium and silicon was photographed with the NBS 10.6-meter Eagle vacuum spectrograph to investigate a portion of the vacuum ultraviolet spectrum of singly ionized copper in first, second, and third orders. 32 of the 33 Cu II lines of the 4p-6s transition for which Ritz calculations have been made were investigated as to their suitability as standards. 104 other lines of Cu II in the interval 861-1623 Å were observed and measured in the second and/or third orders with estimated wavelength uncertainties of 0.0006 Å. Included in this group are two previously unobserved lines of the 4p-6s transition, four members of the calculable 4s-5p transition, and the three ground state transitions (a $^1S_0$-4p $^1P_1$, $^3P_1$, $^3D_1$). This latter group of three lines allows the calculation of shorter wavelength lines.

Some vacuum ultraviolet multiplets of C I, Si II, and Ge II in the wavelength range 1492-1602 Å, were also measured in second order. These lead to an extension, modification or confirmation of the present lists of calculated wavelengths of these spectra. A precise measurement of the Lyman Beta line of hydrogen in third order is an added confirmation of the presence of the Lamb shift of the 1 ^2S state of hydrogen.

9339. **Newly measured and calculated wavelengths in the vacuum ultraviolet spectrum of neutral nitrogen,** V. Kaufman and J. F. Ward, *Appl. Opt.* **6,** No. 1, 43-46 (Jan. 1967).

Key words: Atomic spectrum; calculated wavelengths; nitrogen; spectrum; vacuum ultraviolet.

The NBS 10.7-meter vacuum spectrograph was used in second order to obtain precision measurements on seven N I lines at 1492/4 $(2p^3\,{}^2D^\circ-2p^23s\,{}^2P)$ and 1742/5 Å $(2p^3\,{}^2P^\circ-2p^23s\,{}^2P)$. Combining these values with other available information on the energy levels of the neutral nitrogen atom, 78 calculated wavelengths of N I from 908 to 1745 Å are given with uncertainties of ±0.001 Å or better.

9340. **Nitrogen on rhenium observed with the field emission microscope,** R. Klein and J. W. Little, *Surface Sci.* **6,** No. 2, 193-207 (Feb. 1967).

Key words: Chemisorption; field emission; nitrogen; rhenium.

The adsorption of nitrogen on rhenium was observed with a field emission microscope. Nitrogen decreases the work function of rhenium but also decreases the pre-exponential term of the Fowler-Nordheim expression. The result is a small decrease in emission with nitrogen adsorption. Surface migration could not be directly observed because desorption precedes it. There are two chemisorbed binding states associated with nitrogen on rhenium. The first is little stronger than physisorbed but accounts for most of the nitrogen in a saturated layer at 50 °K. The second is inferred from small pattern changes above 750 °K. The weakly bound state probably consists of a number of states with a distribution of desorption energies.

9341. **A zero-range treatment of the three-body photodisintegration cross section of ^{3}H and ^{3}He,** J. M. Knight, J. S. O'Connell, and F. Prats, *Phys. Letters* **22,** No. 3, 322-325 (Aug. 15, 1966).

Key words: Cross section; differential cross section; ^{3}H; ^{3}He; photodisintegration; zero-range.

Zero-range theory is used to construct bound and continuum state wave functions. The total and differential electric dipole photodisintegration cross sections for three-body breakup of ^{3}He and ^{3}H are calculated using these wave functions.

9342. **New standard for the calibration of microphones,** W. Koidan, *Mag. Std.* **37,** No. 5, 141-144 (May 1966).

Key words: Calibration; microphones; standard.

This article discusses the background, contents and use of a new American Standard, Calibration of Microphones, S1.10-1966, published by the American Standards Association, Incorporated.

9343. **Lack of uniqueness in the International Practical Temperature Scale above the gold point,** H. J. Kostkowski, *Metrologia* **3,** No. 1, 28-29 (Jan. 1967).

Key words: Infrared pyrometer; International Practical Temperature Scale; optical pyrometer; radiation thermometry; standards; temperature.

The International Practical Temperature Scale (IPTS) above the gold point is shown to vary with wavelength. Although the extent of this variation is barely significant relative to the present uncertainty of realizing the scale, the IPTS should be unique; and to achieve this a wavelength must be specified in the definition.

9344. **A new radiometric equation and its application,** H. J. Kostkowski, *Appl. Opt.* **5,** No. 12, 1559 (Dec. 1966).

Key words: Blackbodies; non-blackbody emission; optical radiation; radiometry; sources; spectral radiance.

A simple equation has been found which gives, at any wavelength, the ratio of the spectral radiances of two arbitrary sources when their spectral radiances at some particular wavelength are equal. The main advantages of the equation are its simplicity and the fact that it does not involve temperature explicitly; a limitation is that Wien's radiation equation is required. The new equation is derived and various applications are given.

9345. **Optical constants of germanium,** R. E. LaVilla and H. Mendlowitz, *Appl. Opt.* **6,** No. 1, 61-68 (Jan. 1967).

Key words: Characteristic electron energy loss; far ultraviolet; germanium; Kronig-Kramers dispersion relations; optical properties; sum rules.

We have attempted to assess the disagreement of various investigators on the optical properties of germanium in the far uv. The analysis subjected the reported data, out to about 25 eV to the following tests: 1. An internal consistency check when possible by applying the Kronig-Kramers dispersion relations to the optical constants. 2. An evaluation of the optical oscillator strength distribution for the spectrum under study. 3. Correlation of the values of $\mathrm{Im}\ 1/\epsilon^*$ from the optical data with the characteristic electron energy loss spectrum for the material. 4. Evaluation of the oscillator strength sum for the electron energy loss distribution. A set of optical constants derived from the characteristic electron energy loss data are presented and discussed. Also, an estimate of source of the errors incurred in the application of the Kronig-Kramers dispersion relations are given and discussed in terms of optical data.

9346. **Radiance temperature at 6500 Å of the graphite arc,** R. D. Lee and E. Lewis, *Appl. Opt.* **5,** No. 11, 1858 (Nov. 1966).

Key words: Graphite arc; pyrometry; standard; temperature.

The radiance temperatures of over twenty positive electrodes in a graphite arc were measured with the NBS photoelectric pyrometer and were found to range from 3786 °K to 3808 °K. The radiance temperatures were measured to an accuracy of 2 deg K (standard deviation uncertainty) with a pyrometer sensitivity of 0.2 deg K.

9347. **The NBS photoelectric pyrometer and its use in realizing the International Practical Temperature Scale above 1063 °C,** R. D. Lee, *Metrologia* **2,** No. 4, 150-162 (Oct. 1966).

Key words: Blackbody; International Practical Temperature Scale; optical; photoelectric pyrometer; radiance sources; standards; temperature.

A photoelectric pyrometer has been developed with which the International Practical Temperature Scale (IPTS) above the gold point, 1063 °C, is realized about 5 times more accurately than the prevalently used disappearing filament visual pyrometer. Estimated uncertainties, at a 95% confidence level, of realizing the IPTS with the photoelectric instrument are 0.12 deg C at 1063 °C, 0.24 deg C at 1256 °C, and 3 deg C at 3525 °C. The design, evaluation, and calibration to realize the IPTS are discussed.

9348. **Real two-dimensional representations of the free product of two finite cyclic groups,** J. Lehner and M. Newman, *Proc. Camb. Phil. Soc.* **62,** 135-141 (1966).

Key words: Free products; groups; representations.

All real discrete representations of the free product of two finite cyclic groups by a group of linear fractional transformations are determined.

9349. **Coriolis zeta constants and force field for osmium tetraoxide,** I. W. Levin and S. Abramowitz, *Inorg. Chem.* **5,** 2024-2026 (1966).

Key words: Coriolis constant; force field; infrared; osmium tetraoxide; vibration-rotation.

The infrared spectrum of osmium tetraoxide in the region of its infrared active fundamental absorption bands. Coriolis zeta constants have been determined from the unresolved vibration-rotation band contours. These constants have then been utilized as constraints in the determination of the general force field for osmium tetraoxide.

9350. **Government, industry and engineering. NBS in a new setting,** S. Lichtenstein, *Automotive Ind.* **135,** No. 10, 119-124 (Nov. 15, 1966).

Key words: Basic and applied research; calibration; instrumentation; interchangeability of parts; mass production; standardization; testing.

Sixty-five years of industrial progress—exemplified by the rapid development of the modern, mass-production automotive industry—are discussed in relation to the National Bureau of Standards' 65-year history as the Bureau prepares dedication observances for its new facilities in Gaithersburg. Typical NBS contributions to automotive progress are cited, and they are linked with activities of units devoted to metrology, mechanics, weights and measures, mandatory standards, organic standards, materials evaluation, and product standards.

9351. **The battle against corrosion,** S. Lichtenstein, *Compressed Air Mag.* **71,** No. 12, 12-13 (Dec. 1966).

Key words: Basic and applied research; economics of corrosion; industrial design; materials protection; structural failure.

Corrosion is discussed as a technological and economic "disease" eating away at metals and materials, depleting natural resources, and causing injury and death where accidents and explosions result from weakening of structures. Dollar estimates of costs to the Nation and the Federal Government are given. Anti-corrosion work of the National Bureau of Standards' Institute for Materials Research is described and highlights of a half-century of achievement are noted. Corrosion control is linked to progress in nuclear power, oceanography, water desalination, military operations, space and supersonic transport, health, safety and conservation.

9352. **Nuclear giant quadrupole resonance,** R. Ligensa, W. Greiner, and M. Danos, *Phys. Rev. Letters* **16,** No. 9, 364-367 (Feb. 28, 1966).

Key words: Absorption; collective model; cross section; deformed nuclei; giant quadrupole resonances; photons.

The description of the giant quadrupole resonance of deformed nuclei is extended to include the coupling between the different collective modes. The interaction with the odd particle is also included. The results are compared with recent experimental photon absorption cross sections.

9353. **Current algebras and matrix elements of the axial-vector current,** H. J. Lipkin, H. R. Rubinstein, and S. Meshkov, *Phys. Rev.* **148,** No. 4, 1405-1407 (Aug. 26, 1966).

Key words: Axial-vector current; chiral; G_A; G^*; representation-mixing; sum-rules; vector current.

The assumption that the space integrals of the time components of the vector and axial-vector currents satisfy the commutation rules of the Lie Algebra U(3) x U(3) has led to a number of interesting results. The following experimentally measurable quantities are calculated directly from the algebra without writing down the sum rules: G_A—the strength of the axial-vector coupling constant in β-decays; G^*—the strength of the axial-vector transition between the nucleon and the N*(1238), and the d/f ratio for the axial-vector current of the baryon octet.

9354. **Determination of the effective force constants between a substitutional impurity and its nearest neighbors in an alkali halide crystal,** R. A. MacDonald, *Phys. Rev.* **150,** No. 2, 597-602 (Oct. 14, 1966).

Key words: Alkali halide crystal; Born-Mayer potential; deformation dipole model; effective force constants; isotopic impurities; local mode frequencies; nearest-neighbor interaction; substitutional impurity; U-centers.

The forces between a substitutional impurity and its nearest neighbors in an alkali halide crystal with rocksalt structure are determined in the harmonic approximation. The deformation dipole model is used for the lattice dynamics of the perfect crystal. Two independent force constants are involved in the problem which is treated in two ways. First, the two force constants are obtained from the equation of motion for the local mode of vibration using experimental values of the local mode frequencies due to H^- and D^- impurities in Na*Cl* and K*Cl*, and assuming that the force constants are the same for different isotopes of the impurity. This method yields no real solutions for the force constants for U-centers in K*Cl*. The second method assumes that the force constants for the impurity (say H^-) are the same as those in an alkali hydride crystal having the same lattice spacing as the alkali halide crystal. A Born-Mayer interatomic potential is used for this calculation. The first method gives 45% softening of the force constants for U-centers in Na*Cl*, the second method gives 70% softening. The results are compared with those of previous theories and with experimental results on the KBr:Li^+ system.

9355. **Instrumental aspects of synchrotron XUV spectroscopy,** R. P. Madden, D. L. Ederer, and K. Codling, *Appl. Opt.* **6,** No. 1, 31-38 (Jan. 1967).

Key words: Grazing-incidence; 3-meter; monochromator alignment; 0.06 Å resolution; spectrograph; synchrotron light.

Electron synchrotrons are becoming increasingly important as sources of extreme uv radiation for physical experiments. The NBS 180 MeV machine has been utilized for gas absorption studies over a 4-year period, during which a 3-meter grazing incidence spectrograph and monochromator have been designed, constructed, and put into operation. The instruments are extremely stable to vibration and temperature variation, and are operating with a slit limited resolution of the order of 0.06 Å. The design principles and features of these instruments are described, and a highly-successful prealignment procedure for grazing-incidence spectrometers is outlined. The effect of the unusual characteristics of this light source on the illumination and performance of the spectroscopic instruments is discussed.

9356. **Possible observation of In^{115} nuclear electric hexadecapole transitions,** R. J. Mahler, L. W. James, and W. H. Tantilla, *Phys. Rev. Letters* **16,** No. 7, 259-261 (Feb. 14, 1966).

Key words: Hexadecapole; induced; nuclear; transition; ultrasonically.

This letter reports the observation of ultrasonically induced $\Delta m = \pm 3$, In^{115} nuclear spin transition in InAs single crystal.

9357. **Nuclear hexadecapole interactions,** R. J. Mahler, *Phys. Rev.* **152,** No. 1, 325-330 (Dec. 2, 1966).

Key words: Angular dependence; hexadecapole; hexadecapole transitions; phonon interactions; saturation factor; 4-3m symmetry.

The nuclear hexadecapole matrix elements for the static and the one phonon-nuclear interactions are developed and are evaluated for $\Delta m = \pm 3$ and $\Delta m = \pm 4$ nuclear transitions involving a spin 9/2 nucleus in a crystal with 4-3m symmetry. An expression for the saturation factor for a general interaction which gives rise to nuclear spin transitions involving the change in the z-component of the spin by any amount $\Delta m = \pm n$ is developed and is used to derive the angular variation of the one-phonon, $\Delta m = \pm 3$ and $\Delta m = \pm 4$ nuclear hexadecapole interaction. Finally a method to end the speculation about the observation of the hexadecapole interaction is presented.

9358. **Effects of space radiation on refractive properties of optical glass,** I. H. Malitson, M. J. Dodge, and M. E. Gonshery, *Proc. Annual Conf. Photography, Science and Engineering, San Francisco, Calif., May 9-13, 1966,* p. 75 (1966).

Key words: Optical glasses; radiation effects; refractive index.

A report is given of the effects of gamma and electron radiations on the refractive properties of certain normal and cerium-protected optical glasses that may be used for lens components of high-resolution cameras and television systems. Refractive index changes as large as 2 x 10^{-4} for unprotected glass and 6 x 10^{-5} for non-darkening glasses were observed after irradiation. Data are given showing that radiation-induced index and dispersion changes can last for periods of weeks and fluctuate with time. High purity fused silica was found to be radiation resistant.

9359. **Infrared spectra of HCl, DCl, HBr, and DBr in solid rare-gas matrices,** D. E. Mann, N. Acquista, and D. White, *J. Chem. Phys.* **44,** No. 9, 3453-3467 (May 1966).

Key words: Hydrogen bromide; hydrogen chloride; infrared; rare gas matrix; spectrum.

The infrared absorption spectra of HCl. DCl, HBr, and DBr, trapped in solid rare-gas matrices at liquid hydrogen and liquid helium temperatures, are reported. In the region of their fundamentals, the spectra of all these diatomic molecules consist of a number of bands; some which exhibit reversible changes in intensity and line width with temperature and others which are temperature independent.

The temperature dependent features have been identified as rotation-vibration bands of the matrix isolated diatomic molecule. The spacings of these bands are appreciably less than the separations of corresponding bands in the free molecule spectrum indicating a hindrance to rotation due to lattice-molecule interactions. Two different types of lattice-molecule couplings are examined in the interpretation of the results.

It is shown that the temperature independent bands, identified as vibrational transitions owe their existence to the presence of trace nitrogen impurities in the solidified rare-gas matrices, or concentration effects.

9360. **A pycnometer for small volumes of liquids,** S. Marantz and G. T. Armstrong, *Chem.-Anal.* **55,** 114-115 (Oct. 1966).

Key words: Density; liquids; pycnometer.

The design, calibration, and performance of a small volume (0.1 cm^3) pycnometer is described. The instrument can be used to measure liquid densities to a 0.1 percent accuracy.

9361. **Excitation and ionization in arc and spark spectroscopic sources,** M. Margoshes, *Appl. Spectry.* **21,** No. 2, 92-99 (1967).

Key words: Arc; Boltzmann equilibrium; excitation; ionization; line intensity; Saha equilibrium; spark; spectrochemical analysis; spectroscopic source.

A description is given of the mathematical theories which are applicable to the excitation and ionization of atoms in plasmas at thermal equilibrium. These processes are controlled by the temperature and electron density in the plasma; some methods of determining these parameters are given. It is shown that, even with the limited data available, the theories can be applied to practical problems which arise in spectrochemical analysis.

9362. **Effect of nuclear alignment on the 14 MeV total neutron cross section of ^{165}Ho,** H. Marshak, A. C. B. Richardson, and T. Tamura, *Phys. Rev.* **150,** No. 3, 996-1010 (Oct. 21, 1966).

Key words: Black nucleus model; cryogenic target; coupled-channel calculation; nuclear alignment; nuclear deformation; optical model; Van de Graaff; 14 MeV neutrons; ^{165}Ho.

The effect of nuclear alignment on the total cross section of the highly deformed ^{165}Ho nucleus has been measured using 14 MeV neutrons. The aligned ^{165}Ho target was obtained by cooling a metal single crystal to 0.33 °K. A finely collimated beam of 14 MeV neutrons was produced by careful collimation of the alpha particle produced in the ^{3}H(d,n)^{4}He reaction and by detecting it in fast coincidence with its associated neutron. The measured total cross section is (5.29±0.10) b. The fractional change in the total cross section, for our value of nuclear alignment ($f_2=0.31$), is + (3.52±0.75) %, where the positive sign indicates a larger cross section for nuclei aligned perpendicular to the incident beam than for randomly oriented nuclei. These results are in excellent agreement with the predictions of the optical model using an adiabatic coupled-channel calculation. The optical-model parameters used are in good agreement with those obtained from other measurements, and in particular the value of the deformation parameter $\beta=+0.30$ is the same as that used in our earlier work. It was also found that 14 MeV is not yet a sufficiently high energy to use the black nucleus model to interpret our results.

9363. **X-ray fiber optics,** L. Marton, *Appl. Phys. Letters* **9,** No. 5, 194-195 (Sept. 1, 1966).

Key words: Fiber optics; x rays.

The possibility of the creation of fiber optics for x rays is investigated. While the aims in the creation of such fiber optics are similar to those in light optics, the technical means for achieving it are quite different.

9364. **A nomogram for determining azimuth and horizontal trace velocity from tripartite measurements,** H. Matheson, *Earthquake Notes* **XXXVII,** No. 1, 33-37 (Mar. 1966).

Key words: Nomogram; tripartite nomogram.

The direction normal to a traveling plane wave front and the wave's horizontal trace velocity at the earth's surface, are easily determined by observing the wave at three noncollinear points. Reduction of the data involves the solution of several trigonometric equations. This note describes a nomogram which reduces this task to 30 seconds with ruler and pencil.

9365. **Resonances in inelastic electron scattering from H_2,** M. G. Menendez and H. K. Holt, *J. Chem. Phys.* **45,** No. 8, 2743-2744 (Oct. 15, 1966).

Key words: Electron scattering; H_2, H_2^-; resonances; vibrational excitation.

Resonance structure in the electron scattering from H_2 has been observed in two inelastic channels corresponding to excitation to the first and second vibration levels of $H_2(X^1\Sigma_g^+)$. An overlapping of resonances due to at least two H_2^- states lying between 11 and 13 eV is apparent. The structure in the inelastic channels is compared to the observed resonance structure in the transmission channel. The resonances are found to effect the inelastic channels more strongly than the transmission channel. The excitation function for direct vibrational excitation to the v=1 level was measured near threshold and found to increase approximately linearly in this region.

9366. **Time-dependent behavior of activated molecules. High-pressure unimolecular rate constant and mass spectra,** F. H. Mies and M. Krauss, *J. Chem. Phys.* **45,** No. 12, 4455-4468 (Dec. 15, 1966).

Key words: Activated complex; activated molecules; activated state; decay; dissociation; high pressure rate constant; kinetics; lifetime; mass spectra; metastable molecules; predissociation; quantum mechanics; resonance scattering; theoretical; unimolecular dissociation.

A quantum mechanical theory of the unimolecular decay of metastable, or activated molecules is developed using Fano's treatment of resonance scattering. A resonance state is synonymous with the so-called activated molecule in unimolecular kinetics, and a set of widths are associated with each state which is a measure of the coupling to the various dissociation continuum channels (each channel designates an "activated complex"). If the widths are small compared to the spacings between those neighboring states which are coupled to the same continua, then an ensemble of molecules prepared in a given activated state will decay exponentially in time, as does a radiating or autoionizing excited atomic state. However, unimolecular decay is fundamentally a problem in "overlapping" resonances widths, and is best considered using Fano's theory, which incorporated proper treatment of the overlap. This paper is particularly concerned with the implications of overlapping widths on the high pressure rate constant, and on mass spectra.

There are two effects of overlapping which are most striking. First, the time decay of a metastable moleculc is no longer a pure exponential, but for the special cases considered is represented by a sum of exponential, oscillatory, and/or linear terms, which certainly affects the interpretation of mass spectra. Second, the high pressure rate constant is related to the initial rate of decay of a canonical ensemble of activated molecules, and proper consideration of overlap imposes an upper bound on the rate of dissociation without any artificially imposed restrictions on the widths. This bound yields the "universal rate constant" kT/h times a transmission coefficient which is a function of the widths and *spacings* of the activated molecules, and has an upper limit of one.

9367. **Bandlike structure from continuum-continuum emission: the He_2 600-Å bands,** F. H. Mies and A. L. Smith, *J. Chem. Phys.* **45,** No. 3, 994-1000 (Aug. 1, 1966).

Key words: Atomic; collisions; continuous; deexcitation; He; He_2; metastable; radiative; spectra; theory; vacuum-ultraviolet.

The continuous spectrum produced by the radiative deexcitation of metastable atoms by atom impact is an example of molecular continuum-continuum transitions. It is shown that if the upper molecular state has a deep attractive well and the lower state is repulsive, the continuous spectrum will show banded structure similar to that obtained in bound-continuum transitions from high vibrational states. The analysis is applied to the radiative deexcitation of He(2^1S) by He, which gives rise to the "600 Å bands." The structure and temperature dependence of these bands are well explained as banded continuum-continuum emission. Structured continua observed in other rare gases are discussed in terms of the molecular states involved.

9368. **Infrared spectrum of the free radical CF_3 isolated in inert matrices,** D. E. Milligan, M. E. Jacox, and J. J. Comeford, *J. Chem. Phys.* **44,** No. 10, 4058-4059 (May 1966).

Key words: CF_2 reactions; CF_3 free radical; CF_3Br photolysis; F atom reactions; HCF_3 photolysis; infrared spectrum; matrix isolation technique.

The free radical CF_3 has been stabilized in inert gas and nitrogen matrices at cryogenic temperatures following (1) the reaction of photolytically produced CF_2 and F atoms, (2) the vacuum ultraviolet photolysis of HCF_3 and of CF_3Br, and (3) the reaction of photolytically produced C and F atoms. The concentration of CF_3 obtained in these studies has been sufficient for direct infrared observation of three of its vibrational fundamentals, at 703, 1084, and 1248 cm^{-1}. It is concluded that CF_3, unlike CH_3, is nonplanar in its ground state.

9369. **Matrix-isolation study of the photolysis of cyanogen azide. II. The symmetric stretching fundamental of the free radical NCN,** D. E. Milligan and M. E. Jacox, *J. Chem. Phys.* **45,** No. 5, 1387-1391 (Sept. 1, 1966).

Key words: Carbon atom production; carbon atom reactions; cyanogen azide; force constants; infrared spectrum; NCN free radical; thermodynamic properties; ultraviolet photolysis.

The photolysis of Ar:N_3CN samples at 14 °K with the full light of a cadmium arc has been found to permit complete conversion of the cyanogen azide to the free radical NCN, plus molecular nitrogen. At the high concentration of NCN thus achieved a weak absorption appears at 2672 cm^{-1}. The photolytic behavior of this feature and its shifts upon isotopic substitution support its assignment as the combination band ($\nu_1+\nu_3$) of NCN, permitting deduction of a value of 1197 cm^{-1} for ν_1 of this species. The thermodynamic properties of NCN have been revised in accord with this assignment. The carbon-nitrogen stretching force constant approaches a value characteristic of a doubly bonded species, and the stretching interaction constant is relatively large and positive. Cyanogen azide photolyzes in both its 2750 and its 2200 Å absorption regions to produce NCN+N_2. However, NCN itself photolyzes when subjected to radiation near 2500 Å, producing carbon atoms in the ^3P state, which, in turn, may react with N_2 to form the free radical CNN.

9370. **Unassigned.**

9371. **Recombination of He^+ and He^{++} in the afterglow of a helium discharge,** E. R. Mosburg, Jr., *Phys. Rev.* **152,** No. 1, 166-176 (Dec. 2, 1966).

Key words: Brush-cathode plasma; collisional-radiative recombination; helium afterglow; recombination coefficient.

Studies of the time dependence of atomic and molecular light intensities, electron density, atomic metastable densities and electron temperature have allowed the determination of the He^+—electron recombination coefficient as a function of electron density and temperature. The results are in reasonable agreement with the theory of collisional-radiative recombination. The mechanisms controlling metastable densities and heating of the electron gas are discussed. In particular, the disappearance of the 2^3S metastable atom seems best explained in terms of collisonal de-excitation by electrons.

9372. **A new guide for photographers,** C. S. McCamy, *Mag. Stds.* **37,** No. 8, 223-224 (Aug. 1966).

Key words: Exposure; photography; standards.

The new "American Standard Photographic Exposure Guide" presents and relates data which provide means of calculating camera settings for daylight and moonlight exposure of black-and-white and color films. The appendix gives guidance for photographing sunsets, clouds, the moon, artificial satellites, rainbows, cities at night, fireworks, lightning, aurora, stars, and eclipses. The standard is based on extensive picture tests.

9373. **Concepts, terminology, and notation for optical modulation,** C. S. McCamy, *Photo. Sci. Eng.* **10,** No. 6, 314-325 (Nov.-Dec. 1966).

Key words: Absorptance; contrast; modulation; notation; optical density; propagance; reflectance; reflectance factor; symbols; transmittance; transmittance factor.

Reflectance, transmittance, and optical density are regarded as kinds of flux modulation factors. Transmittance is defined as the ratio of transmitted flux to the incident flux, while transmittance factor is here defined for an optical system as the ratio of the emergent flux with the sample in the system to the emergent flux with the sample removed. Transmission density is defined as the negative logarithm of transmittance factor. This is essentially a new definition to accord with an old practice. Reflection, transmission, and fluorescence are considered generically as propagation and generalized modulation terms are proposed. A coordinate system and functional notation are adopted to systematize the description of optical systems which use or measure modulation. Simplified notation of the form D(g;S:g′;S′) describes most cases. Terms, symbols, and notation are proposed for standardization.

9374. **Mass-spectrometric investigation of the nickel-fluorine surface reaction,** J. D. McKinley, *J. Chem. Phys.* 45, No. 5, 1690-1693 (Sept. 1, 1966).

Key words: Fluorine; high temperature; kinetics; mass spectrometry; nickel; surface reaction.

Mass spectrometric measurements have been made of the reaction of polycrystalline nickel at temperatures between 900 and 1600 °K with fluorine at pressures between 10^{-7} and 10^{-4} torr. Gaseous NiF, NiF_2 and F are the major products, and are formed rapidly on the surface at rates linear with fluorine pressure. NiF is present on the surface over the entire temperature range and desorbs above 1100 °C; the desorption step involves rupture of a Ni(substrate) – NiF bond and has an activation energy of 28 kcal mol^{-1}. NiF_2 formation and desorption are important between 900 and 1600 °K with a maximum rate at 1250-1300 °K. The rate limiting step in the formation of NiF_2 has an activation energy of 39 kcal mol^{-1} and is probably dissociation of fluorine on the surface.

9375. **Classification of normal subgroups of the modular group,** M. Newman, *Trans. Am. Math. Soc.* **126,** No. 2, 267-277 (Feb. 1967).

Key words: Congruence groups; modular group; normal subgroups; parabolic classes.

The normal subgroups of the classical modular group are studied, and theorems such as the following are proved:

(1) There are no normal subgroups of index 12q, where q is a prime > 11.

(2) There are exactly $1+(q/3)$ normal subgroups of index 6q, where q is a prime > 3 and $(q/3)$ is the Legendre symbol.

(3) If there is no normal subgroup of index μ and q is a prime $>\mu$, then there is no normal subgroup of index $q^k\mu$ for all $k \geqq 0$.

9376. **Momentum autocorrelation function for systems with finite spatial boundaries,** R. Nossal, *J. Chem. Phys.* **45,** No. 4, 1097-1100 (Aug. 15, 1966).

Key words: Diffusion coefficients; momentum correlation function; statistical mechanics.

An exact analytical expression is obtained for the momentum autocorrelation function of a particle moving in a one dimensional box and slowed by dynamical friction. Comparison is made with the results of Rahman's computer experiment for liquid Argon.

9377. **Equilibrium pressures of oxygen over Ag_2O – Ag at various temperatures,** E. M. Otto, *J. Electrochem. Soc.* **113,** No. 7, 643-645 (July 1966).

Key words: Dissociation by heat; entropy; equilibrium; heat of reaction; oxygen pressures; silver oxide.

Although earlier investigators showed the dissociation of Ag_2O to be reversible and equilibrium points had been obtained there was a range from 191 to 302 °C that had not been studied. This region has now been studied. From all the data available and heat capacity data $\Delta H°_{298}$ and $\Delta S°_{298}$ have been calculated to be 14.690 kcal/mol O_2 and 31.916 cal/deg, respectively. (1 calorie=4.1840 joules.)

9378. **Conformation of polyesters adsorbed on solid surfaces,** P. Peyser, D. J. Tutas, and R. R. Stromberg, *J. Polymer Sci.* 5, Pt. A-1, 651-663 (1967); *Book, Fundamental Aspects of Fiber Reinforced Plastic Composites,* Ed. R. T. Schwartz and H. S. Schwartz, pp. 163-176 (Interscience Publ., New York, N.Y., 1968).

Key words: Adsorption; configuration of adsorbed polymer; conformation of adsorbed polymer; ellipsometry; infrared; polymer adsorption; polyester.

The conformation of a polyester, poly(ethylene *o*-phthalate), of relatively low molecular weight was studied after adsorption. The extension of the adsorbed molecule in a poor solvent on several planar metal surfaces was studied by ellipsometry and the fraction, *p*, of attached groups on colloidal silica particles in a good solvent was determined by the shift in the infrared absorption frequency between free and adsorbed carbonyl groups. In contrast to previously reported results for polystyrene, the extension normal to the surface remained constant (~70 Å) while the concentration of polymer in the adsorbed film increased during the adsorption period. The value of *p*(0.34 for MW=5400) is relatively high and was independent of surface population for the range of solution concentrations measured. Differences between these results and those for polystyrene are interpreted as resulting from differences in interaction energy and chain stiffness.

9379. **Acoustical thermometer and the National Bureau of Standards provisional temperature scale 2-20 (1965),** H. Plumb and G. Cataland, *Metrologia* **2,** No. 4, 127-139 (Oct. 1966).

Key words: Acoustical thermometry; isotherms below 20 °K; low temperature thermometry; primary thermometry; speed of sound; ultrasonic interferometer.

An acoustical thermometer has been developed at the National Bureau of Standards to determine values of temperature that approximate the Thermodynamic Temperature Scale. The instrument, called an ultrasonic interferometer in acoustical literature, has been used to determine isotherms of the speed of sound in helium gas as a function of pressure. Each isotherm has been extrapolated to zero pressure to approximate the condition of an ideal gas; from the resulting intercepts, values of temperature were calculated.

The instrument and its operation are described and the data for isotherms, which have been determined at approximately every degree from 2-20 °K, are listed. The isotherm data have been treated both graphically and by electronic computer analysis (by the method of least squares) to yield values of temperature that are the basis for a new temperature scale – NBS Provisional Scale 2-20 (1965). When the scale is compared with other existing scales, T_{58} and NBS (1955), in regions of overlap, the agreement with NBS (1955) is excellent but noticeable departures from T_{58} – the helium-4 vapor pressure scale are indicated.

9380. **Microwave spectrum of CF_2,** F. X. Powell and D. R. Lide, Jr., *J. Chem. Phys.* **45,** No. 3, 1067-1068 (Aug. 1, 1966).

Key words: CF_2; dipole moment; free radical; microwave spectrum; structure.

The microwave spectrum of the transient species CF_2 has been detected and analyzed. Eight rotational transitions have been assigned and the rigid-rotor constants determined. The CF distance is found to be 1.30 Å and the FCF angle is 104.9°.

9381. **The RF connector,** R. C. Powell, *Microwave J.* **10,** No. 3, 69 (Feb. 1967).

Key words: Coaxial techniques; precision coaxial measurements; RF connector.

This paper describes the need for and the process of development of precision coaxial techniques. It is intended as an introductory article to an issue devoted to precision coaxial measurements.

9382. **Comparison of Langmuir probe and spectrometric electron temperature measurements,** R. S. Powers, Jr., *J. Appl. Phys.* **37,** No. 10, 3821-3826 (Sept. 1966).

Key words: Electron temperature; Langmuir probe; plasma; spectrometric.

Langmuir probes are often used for temperature measurements in plasmas, due to their convenience and to their ability to give time-resolved measurements. Since probe results are subject to several suspicions, we compare probe and spectrometric electron temperature measurements in a particular low-temperature plasma in which this is possible. We find probe temperatures to be high by amounts between 40 and 4% over an electron temperature range between 410 and 920 °K.

9383. **Low temperature speed of sound in single crystal ice,** T. M. Proctor, Jr., *J. Acoust. Soc. Am.* **39,** No. 5, 972-977 (May 1966).

Key words: Elastic constants; lattice dynamics; lattice parameter changes; single crystal ice; speed of sound; thermodynamic properties.

Only one of the previous measurements of the elastic constants and speed of sound in single-crystal ice-I had been extended below −30 °C. All of the five independent elastic constants have now been measured down to 65 °K. Elastic constant data have been fitted to second-degree polynomials. From these polynomials a 0 °K value for the c_{ij}'s is extracted and a Debye characteristic temperature of 225 °K is calculated. This Debye temperature compares favorably with that previously computed from heat capacity data. No sudden changes in the pseudo-elastic anisotropic factor c_{33}/c_{11} are found to take place at 190 °K as had been previously reported.

9384. **Ionization energies of the neutral rare earths,** J. Reader and J. Sugar, *J. Opt. Soc. Am.* **56,** No. 9, 1189-1194 (Sept. 1966).

Key words: Calculation; ionization; neutral; rare earths; series.

The ionization energies of the neutral rare earths have been derived by means of interpolated values for the differences between the $4f^N6s^2$, $4f^N6s7s$, and $4f^N6s8s$ configurations and the difference in the effective quantum numbers of the $4f^N6s7s$ and the $4f^N6s8s$ configurations. In Ce I the $4f5d^2ns$ series was used. The results in eV are:

Ce I 5.65	Sm I 5.63	Er I 6.10
Pr I 5.42	Eu I 5.68	Tm I 6.18
Nd I 5.49	Dy I 5.93	Yb I 6.25
Pm I 5.55	Ho I 6.02	

The uncertainty is estimated to be ±0.02 eV in all cases but Ce I for which the estimated uncertainty is ±0.06 eV. Values for La I, Gd I, and Lu I obtained spectroscopically by other workers are also tabulated. The present results are compared with those obtained by means of surface ionization. The calculated result for Tb I was inconclusive because of the lack of sufficient knowledge of the energy level structure.

9385. **Comparison of direct and sensitized photolysis of 3-methylpentanal in vapor phase,** R. E. Rebbert and P. J. Ausloos, *J. Am. Chem. Soc.* **89,** No. 7, 1573-1579 (Mar. 29, 1967).

Key words: Aldehyde; energy transfer; photolysis; triplet state; vapor phase.

The direct and the benzene- and acetone-sensitized photolysis of 3-methylpentanal produces butene-1, *trans*-butane-2, and *cis*-butene-2 by an intramolecular rearrangement process in which a hydrogen atom is transferred to the carbonyl group from a γ-carbon atom. In the direct photolysis an increase in temperature or a decrease in wavelength of the incident light results in an increase in the percentage yield of butene-1 and in the ratio *cis/trans*-butene-2. The distribution of the butenes depends upon the amount of energy given to the aldehyde whether by the direct or sensitized photolysis. The benzene- and acetone-sensitized experiments give additional evidence that the intramolecular rearrangement which involves the photo-elimination of olefins can proceed through a triplet excited state. The following additional information was obtained in the course of this study: (1) The aldehyde undergoes both triplet-triplet and singlet-singlet energy transfer with benzene. (2) In the acetone-aldehyde systems only triplet-triplet energy transfer occurs. (3) A comparison of the distribution of butenes which was obtained in the acetone-sensitized experiments with the butene distribution in the direct photolysis at the same temperature indicates that <81 kcal are transferred to the aldehyde by acetone in a triplet-triplet energy transfer reaction.

9386. **Molecular thermodynamics of simple liquids, pure components,** H. Renon, C. A. Eckert, and J. M. Prausnitz, *I&EC Fundamentals* **6,** No. 1, 52-58 (Feb. 1967).

Key words: Argon; molecular complexity; molecular thermodynamics; Prigogine's cell theory; thermodynamic properties; three-parameter theorem.

Thermodynamic properties of simple liquids are calculated from an analytical partition function which is based on a modification of Prigogine's cell theory and on a three-parameter theorem of corresponding states. The partition function gives an excellent representation of the configurational properties of fifteen liquids ranging in molecular complexity from argon to neopentane. Three characteristic molecular parameters are sufficient to calculate the configurational energy and entropy, the volume, coefficient of expansion and compressibility. These parameters are a molecular size, a pair-potential energy, and a term which is closely related to non-central intermolecular forces; this last parameter is a nearly linear function of Pitzer's acentric factor. The main application of this statistical thermodynamic treatment follows from its straightforward extension to liquid mixtures as discussed in Part II.

9387. **Atomic standards of frequency and time,** J. M. Richardson and J. F. Brockman, *Phys. Teacher* **4,** No. 6, 247-256 (Sept. 1966).

Key words: Atomic frequency standards; atomic time; cesium atomic beam; frequency and time standards; standards; standard time scales.

The national standard of time is provided by an atomic device at the National Bureau of Standards. Thus, for the first time in our civilization, the basis of our measurement of time is atomic instead of astronomical. The major reasons for this change are that modern science can measure the resonance of an atom more accurately than it can measure the motions of stars and planets, all of the factors affecting atoms are better understood, and the atomic resonance appears to be more stable than planetary motions. This change has improved our accuracy of measurement by three orders of magnitude.

Presently, the best atomic clocks are based on atomic cesium beams such as the three at NBS. Further research, however, may reveal a better choice of atom or method. NBS is presently using four radio stations to distribute time (and its reciprocal, frequency) to the nation and over much of the globe but, again, research is being conducted on newer techniques which offer higher accuracies.

The change from astronomical to atomic time will have little effect on our daily living habits, but it will permit our technology to accomplish things we couldn't do before and to do the same things more economically.

9388. **Measurements of relative oscillator strengths of some C II multiplets,** J. R. Roberts and K. L. Eckerle, *Phys. Rev.* **153,** No. 1, 87-90 (Jan. 1, 1967).

Key words: Carbon II; coulomb approximation; electron density; electron temperature; equivalent electrons; local thermal equilibrium; oscillator strength (f-value); optical depth; oxygen II; plasma; T-tube.

An electric shock tube (T-tube) filled with a mixture of 95% He and 5% CO_2 at 0.5 torr initial pressure was the source for spectroscopic measurements of some C II oscillator strengths. The absorption oscillator strengths of the C II 2512 Å, 2837 Å, 3920 Å, and 3876 Å multiplets were measured relative to the 4267 Å C II multiplet. The plasma electron temperature was determined by the relative line intensities of the 4254 Å and 4642 Å O II lines.

9389. **The momentum autocorrelation function in a Bernoulli chain,** R. J. Rubin and P. Ullersma, *J. Math. Phys.* **7,** No. 10, 1877-1885 (Oct. 1966).

Key words: Coupled harmonic oscillators; momentum autocorrelation function; statistical dynamics; statistical mechanics.

This paper is devoted to the study of the statistical dynamics of the small amplitude coplanar vibrations of a compound pendulum consisting of $N+1$ particles suspended in series by weightless strings in a gravitational field. All particles have the same mass m, except for the top particle whose mass is $m(1+2)$; and all strings are of equal length. The behavior of this system in the limit in which $N\rightarrow\infty$ is of particular interest because the maximum normal mode frequency is proportional to $N^{1/2}$. In the limit $N\rightarrow\infty$, asymptotic formulas with error estimates are obtained for the time-dependence of the momentum autocorrelation function of: (1) the top particle when $2=0$; (2) the bottom particle when $2=0$; and (3) the top particle when $N\gg2\gg1$.

9390. **An examination of the effects of heat transfer and compressible flow on the performance of laminar flowmeters,** F. W. Ruegg and H. H. Allion, *Proc. Flow Measurement Conf., Am. Soc. Mech. Eng. Fluid Meters Golden Anniversary, Pittsburgh, Pa., Sept. 26-28, 1966,* pp. 253-273 (1966).

Key words: Compressible flow; flowmeter; gas meter; heat transfer; laminar flow; meter calibration.

Laminar meters are now widely used for measurement of gas flow, and high accuracy can be achieved with proper calibration and use. It has been found necessary to modify Poiseuille's law for laminar flow to explain the performance of meters over the wide range of flow conditions encountered. A one-dimensional flow analysis is used to derive the effects of meter shape, heat transfer, and compressibility of the gas on meter performance. A relationship between the meter flow coefficient and the similarity parameters of Reynolds number, Prandtl number, Mach number, and Knudsen number is given in a form that is convenient for both the calibrator and user of the meter. The small but significant effects predicted are compared with experimental results.

9391. **Gas-phase photolysis of isopentane at photon energies below and above the ionization energy,** A. A. Scala and P. Ausloos, *J. Chem. Phys.* **45,** No. 3, 847-854 (Aug. 1, 1966).

Key words: Hydrocarbons; ion-molecule reaction; isopentane; photoionization; photolysis.

The photolysis of $(CH_3)_2CDCH_2CH_3$, $(CH_3)_2CHCH_2CD_3$ and of equimolar $(CH_3)_2CHCH_2CH_3$-$(CD_3)_2CDCD_2CD_3$ mixtures has been investigated in the presence of NO at 1470 Å (8.4 eV), 1236 Å (10 eV) and at 1048 Å-1067 Å (11.54 – 11.72 eV). Furthermore, in order to obtain quantitative information concerning the free radicals produced in the fragmentation processes, $(CD_3)_2CDCD_2CD_3$ has been photolyzed at 1236 Å in the presence of various concentrations of H_2S.

Fragmentation of the excited isopentane molecule produced at 8.4 or 10 eV, as well as of the superexcited molecule formed at 11.54-11.72 eV, yields mainly olefinic products and the following radicals, in order of decreasing yield: $H\cong CH_3\cong C_2H_5\cong C_3H_7$. In addition, on the basis of the various isotopically labeled products, it is concluded that methane, ethane, and propane are split off from the excited isopentane molecule by formation of (a) the corresponding carbene (1,2-elimination), or (b) the corresponding olefin (1,3-elimination). When the energy of the photon is increased from 8.4 to 10.0 eV, the 1,2-elimination processes become more important relative to the 1,3-elimination processes in all cases. At 11.54-11.72 eV, the parent ion decomposes to form methane and ethane mainly by a 1,3-elimination mechanism. It is derived from the results that, in addition to the $C_4H_8^+$ and $C_3H_6^+$ ions formed by the latter fragmentation processes, the ions $C_4H_9^+$ and $C_3H_7^+$ are produced with ion pair yields (M/N) of 0.15 and 0.06, respectively. The ion pair yield of the parent ion is estimated to be 0.35. In contrast to observations derived from an earlier investigation of photoionization of n-butane at 11.54-11.72 eV, an increase in pressure from 0.15 to 15 torr has only a minor effect on the fragmentation of the parent ion.

9392. **Ion-molecule reactions in the condensed phase radiolysis of hydrocarbon mixtures. I. 2-methylbutane and 3-methylpentane,** A. A. Scala, S. G. Lias, and P. Ausloos, *J. Am. Chem. Soc.* 88, No. 24, 5701-5707 (Dec. 20, 1966).

Key words: Ion-molecule reaction; liquid phase photolysis; liquid phase radiolysis; 2-methylbutane; 3-methylpentane.

In the condensed phase, parent ions of 2-methylbutane and 3-methylpentane transfer an H_2-molecule to cyclopropane as well as to smaller unsaturated hydrocarbons according to the reaction: $C_nH_{2n+2}^+ + C_{m'}H_{m''} \rightarrow C_n^+ + C_{m'}H_{m''+2}$. The relative probabilities for the transfer of an H_2-molecule from $C_5H_{12}^+$ to cyclopropane, ethylene, propylene, 1-butene, acetylene, and 2-butene are, respectively, 2.4, 1.4, 1.0, 0.9, 0.77, and <0.1. When cyclopropane-d_6 is added to iso-C_5H_{12}, $CD_2HCD_2CD_2H$ is formed as a product with a yield which increases as the square root of the cyclopropane-d_6 concentration from a G-value of 0.117 at 0.03 mole percent additive to 1.53 at 20 mole percent additive, while all lower perprotonated hydrocarbon products diminish proportionately. Similarly, addition of electron scavengers such as CCl_4 to an i-C_5H_{12}-$(CD_2)_3$ (1:0.03) mixture increases $G(CD_2HCD_2CD_2H)$ to a value as high as 2.85 while the G-value of products such as C_2H_6, C_2H_4, or C_3H_8 drop by factor of five. The importance of the H_2-transfer reaction to our understanding of the condensed phase radiolysis of alkanes is discussed.

9393. **Electron affinity of tungsten determined by its positive and negative self-surface ionization,** M. D. Scheer and J. Fine, *Phys. Rev. Letters* 17, No. 6, 283-284 (Aug. 8, 1966).

Key words: Electron affinity; positive and negative self-surface ionization; tungsten.

It has been shown that negative as well as positive ions are evaporated from an incandescent tungsten surface thereby establishing that the tungsten atom has a positive electron affinity. When equilibrium is assumed between the metal surface and the evaporating ions, a quantitative estimate of the electron affinity can be obtained from a measurement of the positive to negative ion emission ratio at some known surface temperature. Measurements in the 2260 to 2350 °K temperature range yield a value of 0.5 eV for the electron affinity of tungsten.

9394. **The adsorption kinetics of nitrogen on rhenium,** M. D. Scheer and J. D. McKinley, *Surface Sci.* **5**, No. 3, 332-344 (Nov. 1966).

Key words: Adsorption kinetics; nitrogen; rhenium; sticking coefficient; surface coverage.

The adsorption of room temperature nitrogen on atomically clean polycrystalline rhenium has been studied. The sticking coefficients at zero coverage were found to be 0.060, 0.009, and 0.007 at rhenium surface temperatures of 205, 300, and 373 °K respectively. These values are between one and two orders of magnitude smaller than those in the nitrogen-tungsten system. The dependence of the sticking coefficient upon surface coverage and temperature could be accounted for by assuming an intermediate state weakly bound to an adsorption site. These sites were assumed to be uniformly distributed over the surface. Their concentration was found to be less than 1/10 of the number of substrate rhenium atoms/cm². The binding energies of the intermediate state and the permanently adsorbed state were in the ratio of about 1/20 for both the nitrogen-rhenium and nitrogen-tungsten systems. In view of this similarity, it is difficult to account for the large difference in sticking probabilities unless one assumes that tungsten absorbs energy from the intermediate binding state much more efficiently than does the rhenium.

9395. **Ferrimagnetic resonance low-field effects in rod samples,** L. B. Schmidt, R. D. Harrington, and W. E. Case, *Proc. IEEE* **55**, No. 1, 120-121 (Jan. 1967).

Key words: External tensor permeability; ferrimagnetic resonance; ferrites; garnet; low magnetic field effects; permeability; spin waves; tensor permeability; YIG.

A previously unreported absorption which is indicated in the curve of the imaginary part of the external permeability of rod-shaped samples is reported. This curve was transformed from intrinsic permeability data obtained from measurements on polycrystalline garnet samples of different densities. This energy absorption revealed in the loss curve of the external permeability occurs in the vicinity of the dc field at which the intrinsic tensor permeability resonates and appears to be affected by the porosity of the material. The phenomenon is more noticeable at L-band frequencies than at S-band frequencies.

9396. **Flash photolysis of matrix-isolated cyanogen azide in solid nitrogen,** L. J. Schoen, *J. Chem. Phys.* **45**, No. 8, 2773-2776 (Oct. 15, 1966).

Key words: Decay; flash photolysis; lifetime; matrix isolation; primary process.

Flash photolysis combined with matrix isolation spectroscopy has been employed to investigate the decomposition of a cyanogen azide-nitrogen solid at 20.4 °K. Two primary processes have been observed leading to the formation of NCN radicals either in an electronically excited $^1\Delta_g$ level or in the $^3\Sigma_g^-$ ground state. The first order decay of NCN ($^1\Delta_g$) has been studied and the mean lifetime in the solid found to be approximately 500 microseconds.

9397. **Superconductivity in semiconducting SrTIO$_3$,** J. F. Schooley and W. R. Thurber, (Proc. Intern. Conf. Physics of Semiconductors, Kyoto, Japan, Sept. 8-11, 1966), *J. Phys. Soc. Japan* **21**, Paper XVI-2, 639-642 (Suppl. 1966).

Key words: Semiconductors; strontium titanate; superconductivity.

Superconductivity that occurs in a substance which is semiconducting at higher temperatures possesses features which are different from ordinary metallic superconductivity. The occurrence of superconductivity in a material of relatively low charge carrier concentration n_c is due largely to an unusually high density of states at the Fermi surface N(O); heat capacity and superconducting critical field experiments, among others, show the presence of the large N(O). The variability in n_c within an essentially constant electronic energy band structure leads to a corresponding variation in the superconducting transition temperature T_c. The presence of anisotropic Fermi surfaces in multi-valley semiconductors can result in unusually large and anisotropic pressure effects. The relatively low carrier concentrations in semiconductors leads to unusually deep penetration of static magnetic fields in the superconducting state. Finally, the static dielectric constant, which can be quite large in semiconductors, can be varied by combining similar semiconductors into mixed crystals; to the extent that the superconducting properties depend upon the dielectric properties, variation in T_c results.

9398. **The dispersion of distributions derived from folding simple distributions,** R. A. Schrack, *Nucl. Instr. Methods* **45**, No. 2, 319-321 (Dec. 1966).

Key words: Dispersion; distributions; folding; gaussian; square; trapezoidal; triangular.

A graph is presented for obtaining the dispersion (full width at half maximum) of distributions, obtained by folding pairs of simple symmetric distributions. The gaussian, triangular, trapezoidal, and square distributions are considered.

9399. **Divergence in the density expansion of the transport coefficients of a two-dimensional gas,** J. V. Sengers, *Phys. Fluids* **9**, No. 9, 1685-1696 (Sept. 1966).

Key words: Dense gases; rigid disks; rigid spheres; thermal conductivity; transport coefficients; triple collisions; viscosity.

An analysis is presented of the first density correction to the viscosity and thermal conductivity coefficient of a two-dimensional gas of rigid disks. The existence of a divergence in the density expansion is established explicitly. For a two-dimensional gas the triple collision contribution to the transport coefficients diverges logarithmically with the time between collisions. In particular, for rigid disks, the coefficient of the logarithmic singularity in the viscosity and thermal conductivity is evaluated in the first Enskog approximation. The possibility that as a consequence the transport coefficients depend logarithmically on the density is discussed.

9400. **Triple collision contribution to the transport coefficients of a rigid sphere gas,** J. V. Sengers, *Phys. Fluids* **9**, No. 7, 1333-1347 (July 1966).

Key words: Dense gases; rigid spheres; thermal conductivity; transport properties; triple collisions; viscosity.

An analysis is made of the triple collision integrals which appear in the expression for the first density correction to the thermal conductivity and the viscosity of a gas of rigid spheres. It is shown that these triple collision integrals can be written as a sum of integrals associated with six triple collision events, each of which consists of a certain sequence of correlated successive binary collisions. A number of integrations are carried out and the originally 15-fold triple collision integrals are reduced to seven-fold integrals in a form suitable for numerical analysis. The results are compared with the approximate predictions given by the Enskog theory for a dense gas of rigid spheres.

9401. **Correcting for astigmatism in the Czerny-Turner spectrometer and spectrograph,** A. B. Shafer, *Appl. Opt.* **6,** No. 1, 159-160 (Jan. 1967).

Key words: Astigmatism; Czerny-Turner; spectrograph; spectrometer.

It is shown that the Czerny-Turner spectrometer and spectrograph can be made approximately stigmatic by using torroidal mirrors.

9402. **Exactly solvable nonlinear relaxation processes. Systems of coupled harmonic oscillators,** K. E. Shuler and G. H. Weiss, *J. Chem. Phys.* **45,** No. 4, 1105-1110 (Aug. 15, 1966).

Key words: Harmonic oscillators; master equation; nonequilibrium processes; nonlinear relaxation; relaxation processes; stochastic processes.

A class of nonlinear relaxation processes is discussed which involves the interaction of two finite systems characterized by special forms of the transition probabilities. For the particular set of transition probabilities it is possible to reduce the initial set of coupled nonlinear kinetic equations to a set of linear equations with time dependent coefficients which are amenable to exact analytical solutions. This reduction is effected through the use of summational invariants expressed in terms of the appropriate combinations of the moments of the distribution functions of the two systems. The vibrational-vibrational relaxation of two interacting systems of harmonic oscillators A and B has been worked out as a specific example. For the type of relaxation processes discussed here it is found that the relaxation of system A is independent of the form of the initial distribution of system B (and thus of its time history) and vice versa.

9403. **Observation of the $D^1\Delta \leftarrow X^1\Sigma^+$ transition of CO in the vacuum-ultraviolet region,** J. D. Simmons and S. G. Tilford, *J. Chem. Phys.* **45,** No. 8, 2965-2968 (Oct. 15, 1966).

Key words: Absorption spectrum; CO; diatomic spectrum; electronic transition; rotational analysis; vacuum-ultraviolet region.

A weak new band in the vacuum-ultraviolet absorption spectrum of CO has been observed and analyzed as the $D^1\Delta \leftarrow X^1\Sigma^+(1\text{-}0)$ band for both $C^{12}O^{16}$ and $C^{13}O^{16}$. The observed rotational intensity distribution indicates this transition arises through mixing of the $D^1\Delta$ state with neighboring states, principally the $A^1\Pi$ state of the strong electric-dipole-allowed fourth-positive system. A brief correlation of observed electronic states with those arising from various electronic configurations is given.

9404. **Angle and channel dependence of resonance in e-He scattering near 60 eV,** J. A. Simpson, M. G. Menendez, and S. R. Mielczarek, *Phys. Rev.* **150,** No. 1, 76-78 (Oct. 7, 1966).

Key words: Angular difference; He, He^-; inelastic scattering; resonances; scattering.

The He^- resonances at 57.1 and 58.2 eV in the electron scattering from He were studied as a function of angle in three inelastic channels corresponding to excitation of the $(1s2s)^3S$, $(1s2s)^1S$, and $(1s2p)^1P$ states of He. The line shapes of the resonances are found to vary with angle. The use of the Fano-Cooper formula, developed for the case of photon absorption, to resonances in inelastic electron scattering is discussed along with a simple procedure for determining the line profile indices. The angular dependence of the ^1S, ^3S, and ^1P excitations at 56.5 eV was also measured out to about 60°.

9405. **Anomalous energy spreads in electron beams,** J. A. Simpson and C. E. Kuyatt, *J. Appl. Phys.* **37,** No. 10, 3805-3809 (Sept. 1966).

Key words: Electron beams; energy distribution.

Energy distributions of 2 to 10 eV electron beams were measured in a deflection analyzer. The performance of the analyzer was monitored by use of a second one in tandem. In agreement with earlier measurements in higher energy beams the energy distribution varied with current. At low currents the energy distribution was Maxwellian at a temperature corresponding to the cathode temperature. As the current increased toward the space charge limit the energy width increased. The excess energy width could be fitted to a curve linear in maximum current density and varying inversely with beam energy to the three-halves power. No shift in most probable energy was found. The results are not in quantitative agreement with the higher energy low space charge measurements.

9406. **The new tungsten-filament lamp standards of total irradiance,** R. Stair, W. E. Schneider, and W. B. Fussell, *Appl. Opt.* **6,** No. 1, 101-105 (Jan. 1967).

Key words: Blackbody; lamp standard; total irradiance.

The NBS standard of total irradiance as presently issued in the form of a 50-watt carbon filament lamp was originally calibrated more than 50 years ago. Recently, needs for higher accuracy and wider ranges of total irradiance have necessitated the setting up of three sizes (100-, 500-, and 1000-watt) of tungsten-filament lamp standards of total irradiance. These standards operate at a higher temperature than was possible with the carbon-filament lamps, and are shielded, except for a narrow area of the bulb in front of the filament, so that the reception of long-wavelength flux from the lamps is reduced to a minimum. The new lamps were calibrated by the use of a blackbody at a known temperature together with a quartz plate whose spectral transmittance was accurately determined. The quartz plate limits the flux received from the blackbody to the spectral region below about 4.5 microns and thus reduces errors resulting from water vapor absorption at 6 microns and longer wavelengths. Comparisons show the new standards to be in close agreement with the carbon-filament lamp standard.

9407. **Resolving power predictions from lens design data,** O. N. Stavroudis, *Appl. Opt.* **6,** No. 1, 129-135 (Jan. 1967).

Key words: Correlation; lens design; resolving power.

A relationship between longitudinal spherical and longitudinal chromatic aberration and resolving power is discussed and an experiment using this relationship to predict resolving power from design data is described. The results show a high degree of correlation between resolving power predicted by this method and that obtained by measurement on real lenses.

9408. **Glass-molten salt interactions,** K. H. Stern, *Chem. Rev.* **66,** No. 4, 355-372 (July 25, 1966).

Key words: Conductance; diffusion; electrodes; electrolysis; glass; molten salts.

Phenomena involved in the interactions between glass and molten salts are described and discussed. These include diffusion and electrochemical phenomena occurring at the glass-molten salt interface. Their application to the design of glass membrane reference electrodes for use in molten salts is discussed. The electrical properties of glass at elevated temperatures are considered from a mechanistic point of view.

9409. **Observation of the superconducting energy gap in a semiconductor (GeTe),** P. J. Stiles, L. Esaki, and J. F. Schooley, *Phys. Letters* **23,** No. 3, 206-207 (Oct. 17, 1966).

Key words: GeTe; semiconductor; superconducting energy gap; tunnel junction.

A report of the first observation of the superconducting energy gap in a semiconductor, GeTe, is given. The gap was observed in a tunnel junction of Al-Al_2O_3-GeTe.

9410. **Lightness change of grays induced by change in reflectance of gray background,** H. Takasaki, *J. Opt. Soc. Am.* **56,** No. 4, 504-509 (Apr. 1966).

Key words: Contrast; crispening; lightness; Munsell value; reflectance.

A relatively small gray sample looks lighter (darker) when it is placed on darker (lighter) background. This phenomenon is an example of the well-known contrast effect. The purpose of this paper is to make a quantitative determination of the effect, and to derive a formula for it.

For any given gray sample and gray surround on the left side, the observer was instructed to choose, for the different gray surround on the right, a different gray sample appearing equally light as that on the left. It was found that lightness of a sample changes rapidly with regard to its reflectance when this reflectance is close to that of background. This effect was named the "crispening effect".

Several models (Von Kries coefficient law, Hurvich-Jameson induction) were tried, but none of them reproduced the experimentally discovered crispening effect. A fairly successful empirical formula was developed by adding to the formula for the induction theory a term for the crispening effect.

9411. **Chromatic changes induced by changes in chromaticity of background of constant lightness,** H. Takasaki, *J. Opt. Soc. Am.* **57,** No. 1, 93-96 (Jan. 1967).

Key words: Chromatic induction; color; contrast; crispening; opponent color theory; surround color; three components color theory.

A relatively small gray sample looks reddish (greenish) when it is placed on a green (red) background, and yellowish (bluish) when it is placed on a blue (yellow) background. This phenomenon is an example of the well-known contrast effect. The purpose of this paper is to make a quantitative determination of the effect, and to check whether the empirical formula previously derived for lightness contrast applies also to chromatic contrast. Two series of color samples were prepared so that in the dominator-modulator system proposed by Judd, only one of the three fundamental responses varied. For a given member of one of these two series viewed on a surround of any member of the same series on the left side, the observer was instructed to choose, for a surround of a different member of the series on the right, the member of the series producing most nearly the same color appearance. The crispening effect which was found in lightness was also found in each of the chromatic responses, green and violet; and the empirical formula derived for lightness contrast was found to apply with fair success to the observations of each of the five observers, each with a different set of constants.

9412. **Zeeman effect and magnetic hyperfine structure in the low frequency transitions of H_2CO,** H. Takuma, K. M. Evenson, and T. Shigenari, *J. Phys. Soc.* **21,** 1622-1623 (1966).

Key words: H_2CO; magnetic hyperfine structure; RF transition; Zeeman effect.

The Zeeman structure and the center frequencies of the $4_{31}\rightarrow 4_{32}$ and the $5_{32}\rightarrow 5_{33}$ transition of H_2CO were measured. The spectra agreed with theory using recently redetermined molecular constants.

9413. **Micrometer U-tube manometers for medium-vacuum measurements,** A. M. Thomas and J. L. Cross, *J. Vacuum Sci. Technol.* **4,** No. 1, 1-5 (Jan.-Feb. 1967).

Key words: Manometers; mercury; micrometer; oil; U-tube; vacuum measurement; water.

A family of U-tube manometers, suitable for use as standard instruments, has been designed and constructed at the National Bureau of Standards to cover the range of pressures from 100 to 1×10^{-2} torr. In these instruments the levels of the two liquid surfaces are measured by adjusting micrometers with conical points ground on the ends of the spindles. One hundred mm and fifty mm range mercury manometers, with spindles approaching the liquid surface from above, are used for differential or absolute pressure measurements up to 100 torr. Pressures less than 3.5 torr are measured with oil manometers, in which the micrometer spindles approach the surfaces from below. Measurements made with the mercury manometer have an uncertainty of about 4×10^{-3} torr plus eight parts in one hundred thousand of the reading. Measurements made with the oil manometer have an uncertainty of about 4×10^{-4} torr plus two parts in ten thousand of the reading.

9414. **Intramolecular insertion of isobutylidene in the vacuum ultraviolet photolysis of isobutane,** E. Tschuikow-Roux and J. R. McNesby, *Trans. Farady Soc.* **62,** No. 524, 2158-2163 (Aug. 1966).

Key words: Insertion; isobutane; isobutylidene; photolysis; vacuum ultraviolet.

The direct photolysis of isobutane was carried out at the Xe resonance line (1470 Å) at 25 °C over the pressure range 5.3 to 410 torr (1 torr = 1/760 atmos = 133.32 N/m^2) with and without added nitrogen. Specifically, evidence for the intramolecular insertion of isobutylidene resulting from the carbene elimination of H_2 was sought and found. From the C_4 product distribution at the highest pressure it was deduced that the ratio of isomerization of isobutylidene to intramolecular cyclization is 19:1.

9415. **Reactions of ethylidene in the vacuum ultraviolet photolysis of ethylene,** E. Tschuikow-Roux, J. R. McNesby, W. M. Jackson, and J. L. Faris, *J. Phys. Chem.* **71,** No. 5, 1531-1533 (April 1967).

Key words: Carbene; ethylene; ethylidene; gas phase; photolysis; solid phase; vacuum ultraviolet.

Ethylene was photolyzed at the 1470 Å Xe resonance line both in the gas and solid phase (36 °K). The gas phase photolysis gave no products characteristic of bimolecular reactions of ethylidene. However, in the condensed phase, photolysis gives methylcyclopropane and much larger amounts of cyclopropene and methylcyclopropene. The mechanisms of production of these products are discussed as well as the relationship of ethylene photolysis to the photolysis of other sources of ethylidene.

9416. **Electronically excited NO by photodissociation of NO_2 and NOCl,** K. H. Welge, *J. Chem. Phys.* **45,** No. 4, 1113-1117 (Aug. 15, 1966).

Key words: Fluorescence; nitric oxide; nitrogen dioxide; nitrosyl chloride; vacuum ultraviolet.

The photodissociations of NO_2 and NOCl yielding electronically excited NO are observed by the fluorescence of NO(γ) and NO(β) bands:

$$NO_2 \xrightarrow{h\nu} NO(A\,^2\Sigma^+, v=0) + O(^3P)$$

$$NO_2 \xrightarrow{h\nu} NO(B\,^2\Pi, v=0, 1, 2, 3) + O(^3P)$$

$$NOCl \xrightarrow{h\nu} NO(A\,^2\Sigma^+, v=0, 1, 2) + Cl(^2P^0)$$

Dissociation of NO_2 is observed at wavelengths 1165, 1236, and 1295 Å but not at 1470 Å and longer wavelengths. Dissociation of NOCl is found at wavelengths from 1165 Å up to about 1600 Å. The $NO(A^2\Sigma^+)$ and $NO(B^2\Pi)$ molecules from NO_2 and NOCl are strongly rotationally excited.

9417. **Formation of $NH(c^1\Pi)$ and $NH(A^3\Pi_i)$ in the vacuum-uv photolysis of HN_3,** K. H. Welge, *J. Chem. Phys.* **45,** No. 11, 4373-4374 (Dec. 1, 1966).

Key words: Fluorescence; hydrazoic acid; NH; photolysis; vacuum ultraviolet.

The fluorescence of $NH(c^1\Pi, v=0,1)$ and $NH(A^3\Pi_i, v=0,1)$ is obtained when HN_3 is photolyzed in a flow system at wavelengths from 1236 Å up to about 1750 Å. Rotational levels of the $c^1\Pi$, $v=0$ state are observed up to $K\simeq20$.

The formation of $NH(c^1\Pi)$ is attributed to the photodissociation of HN_3 into $N_2(X^1\Sigma_g^+)+NH(c^1\Pi)$ and that of $NH(A^3\Pi_i)$ to some not identified secondary reactions. This explanation is based on the finding that the $NH(c^1\Pi)$ emission is not affected by the flow rate whereas the $NH(A^3\Pi_i)$ emission decreased with increasing flow rate.

9418. **Formation of $N_2(A^3\Sigma^+)$ and $N(^2D,^2P)$ by photodissociation of HN_3 and N_2O and their reactions with NO and N_2O,** K. H. Welge, *J. Chem. Phys.* **45,** No. 1, 166-170 (July 1, 1966).

Key words: Energy transfer; fluorescence; hydrazoic acid; nitrous oxide; photolysis.

The formation of $NO(A^2\Sigma^+)$ and $NO(B^2\Pi)$ in the photolysis of N_2O at 1236 Å and 1470 Å was investigated by observing the fluorescence of the γ and β bands. The β band fluorescence is obtained when pure N_2O is photolyzed at 1236 Å and 1470 Å in a flow system. The β bands are observed with vibrational excitation up to $V'=3$. The β bands disappear with the addition of small amounts of NO whereas the emission of rotationally hot γ bands is obtained. The γ bands are observed with vibrational excitation up to $v'=2$. According to the energetics, $NO(A^2\Sigma^+)$ and $NO(B^2\Pi)$ are formed at 1470 Å as well as at 1236 Å not by direct photodissociation of N_2O but by secondary reactions. No fluorescence is obtained when N_2O or N_2O/NO mixtures are irradiated at wavelengths ≧ 1600 Å, i.e., within the long wavelength absorption band of N_2O.

The γ and β band fluorescence is explained by the following mechanism: photodissociation of N_2O At 1236 Å and 1470 Å,

$$N_2(A^3\Sigma_u^+)+O(^3P)$$

$$N_2O$$

$$N(^2D \text{ and/or } ^2P)+NO(X^2\Pi),$$

followed by the reaction

$$N(^2D \text{ and/or } ^2P)+N_2O\rightarrow NO(B^2\Pi)+N_2$$

$$NO(B^2\Pi)\rightarrow NO(X^2\Pi)+\beta \text{ bands.}$$

This reaction is intercepted effectively by NO, possibly through

$$N(^2D \text{ and/or } ^2P)+NO\rightarrow N_2+O$$

thus causing the disappearance of the β band emission with the addition of NO. At sufficiently high concentration, NO reacts with $N_2(A^3\Sigma_u^+)$ via

$$N_2(A^3\Sigma_u^+)+NO(X^2\Pi)\rightarrow N_2(X^1\Sigma_g^+)+NO(A^2\Sigma^+)$$

$$NO(A^2\Sigma^+)\rightarrow NO(X^2\Pi)+\gamma \text{ bands.}$$

The emission of γ bands is also obtained in the photolysis of HN_3/NO mixtures at 1470 Å and 1236 Å. This observation is explained by the photodissociation

$$HN_3\rightarrow N_2(A^3\Sigma_u^+)\rightarrow NH(X^3\Sigma^-)$$

followed by the above reaction between $N_2(A^3\Sigma_u^+)$ and NO, yielding $NO(A^2\Sigma^+)$. The other possibility, that O atoms which are formed by photodissociation of NO react with HN_3 to form excited NO – as in the O/N_2H_4 atomic flame – is excluded.

9419. **EPR in single crystals of $NiBr_2$,** J. S. Wells and D. R. Winder, *J. Chem. Phys.* **45,** No. 1, 410-411 (July 1, 1966).

Key words: Antiferromagnetic; EPR; g value; K-band spectrometer; $NiBr_2$; single crystal.

Previously reported EPR measurements on $NiBr_2$ gave a single g value and linewidth for the resonance in a powdered sample. We have made measurements with a K-band spectrometer on a single crystal of this material as work preliminary to measuring the internal fields in the antiferromagnetic state. The spectra have been examined at 300 and 76 °K. At 300 °K, $g_\perp=2.21\pm0.02$, $g_\|=2.19\pm0.02$, $\Delta H_\perp=800$ gauss and $\Delta H_\|=1000$ gauss. At 76 °K, $g_\perp=2.23\pm0.01$, $g_\|=2.16\pm0.01$, $\Delta H_\perp=400$ gauss and $\Delta H_\|=600$ gauss. At 4 °K, the resonance was not observed within the range of our spectrometer.

9420. **Matrix elements of general potentials in the harmonic-oscillator representation,** R. M. Wilcox, *J. Chem. Phys.* **45,** No. 9, 3312-3316 (Nov. 1, 1966).

Key words: Fourier transform; function V(q); harmonic oscillator; matrix elements.

The m, n matrix element of an arbitrary potential function V(q) in the one-dimensional harmonic oscillator representation is shown to be given by

$$\langle m|V(q)|n\rangle=\sum_{r=0}^{m}\frac{\alpha[m!n!]^{1/2}}{r!(m-r)!(n-r)!}\int_{-\infty}^{\infty}dyg(\alpha y)e^{-1/2y2}(iy)^{m+n-2r},$$

where $\alpha\equiv(2\omega/\hbar)^{1/2}$, and $g(\alpha y)$ is the Fourier transform of V(g). This formula is specialized to the cases where V(g) is given by $q^je^{-1/2}\gamma q^2$, $e^i\alpha^{uq}$, and $q^{-1}\sin(\alpha\lambda q)$, where j is a non-negative integer and γ, u, and λ are real parameters. Results are compared, where possible, with previous work.

9421. **Chemisorption of nitric oxide on tungsten,** J. T. Yates, Jr. and T. E. Madey, *J. Chem. Phys.* **45,** No. 5, 1623-1634 (Sept. 1, 1966).

Key words: Adsorption; chemisorption; desorption; dissociation; field emission microscopy; kinetic; nitric oxide; surface; surface diffusion; tungsten; work function.

The chemisorption of NO on polycrystalline W has been investigated using a combination of ultrahigh vacuum techniques: flash desorption mass spectroscopy and field emission microscopy. It has been found that NO chemisorbs non-dissociatively on W at room temperature. Dissociation occurs at elevated temperature with an activation energy of about 47 kcal/mole (197 kJ/mole). Kinetic evidence indicates that dissociation involves the interaction of an adsorbed NO molecule with a neighbor empty site. At high NO coverage, dissociation is rate controlling for the liberation of ω-mode nitrogen near 1000 °K. Heating of an NO-shadowed W field emission tip above ~700 °K results in the formation of a *receding* boundary which remains sharp during the entire course of its backward motion over the initially covered region. This behavior is consistent with a model involving dissociation of NO at the boundary where empty sites are available. For monolayer NO (1.4×10^{15} molecules cm^{-2}) on polycrystalline W, $\Delta\phi=+1.85\pm0.10$ eV; this corresponds to an average surface dipole moment of 0.35 debye per chemisorbed NO molecule at full coverage.

9422. **The effect of other metallic ions on the electrocrystallization of silver from nitrate solutions,** J. P. Young, *Plating* **54,** No. 3, 272-274 (Mar. 1967).

Key words: Crystal growth; dendrite; electrocrystallization; electrodeposited crystals; electrodeposited dendrites; silver.

Silver dendrites of various configuration and forms were grown electrolytically on small cathode surfaces in silver nitrate solutions to which small amounts of other metal ions had been added to alter the characteristics of the non-epitaxial silver formations.

9423. **Effect of surface patch fields on field-emission work-function determinations,** R. D. Young and H. E. Clark, *Phys. Rev. Letters* **17,** No. 7, 351-353 (Aug. 15, 1966).

Key words: Energy distribution; field emission; patch fields; single crystal planes; work function.

Laplace's equation is used to show that substantial electrostatic patch fields exist on field emission tips due to work function differences over the various single-crystal planes. The implications of these previously neglected fields are discussed in regard to their effect on measurements of work function. A derivation is given for a new energy distribution method of determining work functions, and a method is suggested for obtaining values of work function which are independent of both the patch fields and the applied field.

9424. **Anomalous work function of the tungsten (110) plane,** R. D. Young and H. E. Clark, *Appl. Phys. Letters* **9,** No. 7, 265-268 (Oct. 1, 1966).

Key words: Energy distribution; field emission; patch fields; tungsten; work function; (110) plane.

Work function measurements have been carried out on the densely packed (110) plane of tungsten. Field ion microscope techniques have been used to obtain atomically perfect single crystal (110) planes. Field electron emission energy distributions have been combined with Fowler-Nordheim measurements to give work function values at 77 °K. The electrostatic patch fields which exist at the measured surface result in corrections which tend to increase the work function value. The measurements reported here are not corrected for patch fields and range in value from 7.1 eV to 8.7 eV for the (110) plane. Future measurements will employ a newly discovered technique involving a family of energy distribution plots which eliminates the correction for patch fields.

9425. **Translational diffusion in polymer solutions,** R. Zwanzig, *J. Chem. Phys.* **45,** No. 5, 1858-1859 (Sept. 1, 1966).

Key words: Diffusion coefficient; polymer; solution; theory.

Kirkwood's theory of the translational diffusion coefficient of a polymer molecule in solution is criticized. It is shown to give incorrect results, by a factor of 11/12, for a rigid ring-shaped polymer.

9426. **Ground state of bis(acetylacetonato) copper (II),** H. C. Allen, Jr., *J. Chem. Phys.* **45,** No. 2, 553-555 (July 15, 1966).

Key words: Bis(acetylacetonato) copper (II); bis(3-phenyl-2,4-pentanedionato copper (II); crystal spectrum; polarized spectrum.

Existing data on the polarized crystal spectrum of bis(acetylacetonato) copper (II) are interpreted. Through the use of a lower molecular symmetry than had previously been used, it is possible to present an interpretation consistent with that for the spectra of other bis copper (II) chelates.

9427. **A network-simulation approach to the railroad freight train scheduling and car sorting problem,** W. P. Allman, *Proc. 4th Intern. Conf. Operational Research, Boston, Mass., Aug. 29-Sept. 2, 1966,* (Arthur D. Little Inc., Cambridge, Mass., 1966).

Key words: Freight operations; GPSS; railroads; scheduling; SIMSCRIPT; simulation; sorting.

These interdependent questions must be answered simultaneously, and in accordance with overall operating objectives of the railroad interprise. Policies must be revised periodically when significant changes in demand traffic patterns occur.

The paper describes a simulation model which permits experimentation with various alternative railroads freight operating policies at a total-network level. The model has been constructed with the SIMSCRIPT simulation programming language. Model inputs include time-dependent freight car origin-destination demand data, train routes and schedules, yard sorting and operation policies, and assignments of cars to trains for hauling. Freight cars are sorted at yards, and picked up and dropped off by trains which haul them thru the network. Model outputs include several railroad operation performance measures such as origin-destination transit times, activity volumes, train lengths, delays incurred by cars at yard operations, and operating costs.

9428. **Mass flowmeters in cryogenic service,** W. J. Alspach, C. E. Miller, and T. M. Flynn, (Proc. ASME Flow Measurement Conf., Pittsburgh, Pa., Sept. 26-28, 1966), *Book, Flow Measurement Symposium,* pp. 34-56 (American Society of Mechanical Engineers, Pittsburgh, Pa., Sept. 1966); *Mech. Eng.* **89,** No. 5, 105-113 (May 1967).

Key words: Accuracy; calibration; commodity transfer; cryogenic; cryogenic processes; density; flowmeters; mass flow; mass flowmeters; performance results; propellant management; substitute fluid; volume flow.

This paper concerns cryogenic fluid mass flow measurement by a variety of techniques, including those that are available and those that are being developed. Attention is given to the principle of operation, performance results, and operational and design characteristics.

The problem of cryogenic fluid flowmeter calibration is examined and discussed with reference to available facilities, techniques, limitations, and accuracy. The problem of calibration for special cryogenic applications, such as slush hydrogen and cold gasses, where no calibration facilities are available is also examined. Inferred calibration from a substitute fluid calibration or design practices is also reviewed.

To improve the mass flow measurement of cryogenic fluids, discussions are directed towards measurement technique selection, density measurements for inferential mass systems, improvements in volumetric flow measurements, improvements in direct measuring mass flowmeters, and improvements in calibration.

9429. **Cryogenic coil for megajoule energy storage,** V. Arp, *Proc. Intern. Symp. Magnet Technology,* Ed. H. Brechna and H. S. Gordon, pp. 625-629, (U.S. Atomic Energy Commission, 1965).

Key words: Aluminum; cryogenic magnet; energy storage; induction coil; liquid hydrogen.

A liquid hydrogen cooled induction coil is being constructed for short time energy storage of 10^6 joules. The coil is made of very pure aluminum having an electrical resistivity of about 3 x 10^{-9} ohm cm at 20 °K. The coil parameters are dictated by its proposed use for the Army Missile Command, and are as follows: inductance of 50μ henries, charging time of 10 seconds or less from zero to peak current of 200,000 amperes, and maximum terminal voltage during discharge of 12,000 volts. The coil will be housed in a non-metallic dewar, and powered from batteries. Details of the coil and cryostat design and electrical circuits will be discussed. The basic design is capable of being pushed to higher energy storage without major difficulty.

9430. **Electron microscopy and diffraction of synthetic corundum crystals. II. Dislocations and grain boundaries in impurity-doped aluminium oxide,** D. J. Barber and N. J. Tighe, *Phil. Mag.* **14,** No. 129, 531-544 (Sept. 1966).

Key words: Aluminium oxide; dislocations; electron microscopy; grain boundaries; impurities; sapphire.

Boules of aluminium oxide containing various impurities, grown by the Verneuil technique, have been examined by transmission electron microscopy. Most of the samples have dislocation densities $\sim 6 \times 10^5$ cm^{-2}, excluding grain boundaries. This is two orders of magnitude higher than that for comparable undoped crystals. There is a higher incidence of low angle boundaries and the characteristics of these are described. The samples rarely contain internal precipitates; furthermore, precipitates in sapphire do not normally create significant numbers of dislocations.

The interactions of a singularity with a basal network of dislocations with 1/3 $\langle 11\bar{2}0\rangle$ Burgers vectors are analyzed. The configuration is not consistent with the singularity being a $\langle 10\bar{1}0\rangle$ dislocation, but it can be explained by assigning the singularity a 1/3 $\langle 10\bar{1}1\rangle$ vector.

9431. **The determination of mercury in latex paints and paint films containing mercury fungicides,** H. W. Berger, *J. Paint Technol.* **38,** No. 498, 371-376 (July 1966).

Key words: Analysis; colorimetric; dithizone; paint film; fungicide; latex; mercury; paint.

A new method has been developed for the spectrophotometric analysis of mercury in latex paints. The method, based on the complexing of Hg(II) with diphenylthiocarbazone, can be used to assay the mercury in the whole paint, the dry film, and in commercial fungicides, as well as other industrial and agricultural materials. The procedure is rapid, requires only simple techniques, and is capable of an average accuracy of 1%. Inorganic pigments, and other components usually found in latex paints, do not interfere with the analysis.

9432. **Roofing research,** T. H. Boone, *Military Engr.* **58,** No. 385, 344-345 (Sept.-Oct. 1966).

Key words: Liquid-applied coatings; membrane movements; prefabricated sheets; radiative cooling; roofing research; solar heating.

The Building Research Division of the National Bureau of Standards has for many years studied roof systems, constituent materials and components. Highlights of the roofing research in the last five years and a brief resume of the results of this research are given. Description of some of the newly-developed roofing systems and the present status of roofing research are also discussed.

9433. **Adhesive bonding of various materials to hard tooth tissues. VI. Forces developing in direct-filling materials during hardening,** R. L. Bowen, *J. Am. Dental Assoc.* **74,** No. 3, 439-445 (Feb. 1967).

Key words: Adhesion; bonding; dental; filling materials; hardening; shrinkage; strain; stress; tensile.

Tensile forces will develop when dental filling materials shrink as they harden within a cavity, if there is bonding to the cavity walls. A test method was devised by which these forces could be measured. This was done by observing the loading required to maintain constant distance between two opposing walls (having known area) of an artificial cavity. If several broad assumptions are made, it can be estimated that a tensile stress of at least 49 kg/cm^2 (700 psi) at the walls of a cavity may develop during the hardening of a direct filling resin. The corresponding stress for a silicate cement would be about 35 kg/cm^2 (500 psi). Other direct filling materials were also investigated. The magnitude of the stress depended on the exact test method, the material, and other factors.

The strength of adhesive bonding between a direct filling material and the cavity walls of a tooth must exceed the tensile stresses that develop during the hardening of the filling material, if the bonding is to remain intact.

9434. **Dielectric constants of $PbMoO_4$ and $CaMoO_4$,** W. S. Brower and P. H. Fang, *Phys. Rev.* **149,** No. 2, 646 (Sept. 16, 1966).

Key words: Calcium molybdate; dielectric constant; lead molybdate; single crystal.

The dielectric constants ϵ' of $PbMoO_4$ and $CaMoO_4$ were measured at 24.5 °C in air. Two specimens of each orientation were measured. The average values and the deviations for the measured dielectric constants are as follows: $PbMoO_4$:$\epsilon' \parallel a$, 34.0±0.4; $\epsilon' \parallel c$, 40.6±0.2; $CaMoO_4$:$\epsilon' \parallel a$, 24.0±0.2; $\epsilon' \parallel c$, 20.0±0.2.

9435. **Measurement of thermal neutron flux,** R. S. Carter, C. O. Muehlhause, and V. W. Meyers, *IEEE Trans. Nucl. Sci.* **NS-14,** No. 1, 414-415 (Feb. 1967).

Key words: Absolute gamma ray source strength; black glass beads; thermal neutron flux.

A new technique has been developed for the measurement of thermal neutron flux. Small glass beads ($\sim$1 mm radius) are made black to thermal neutrons by the inclusion of B^{10}. In addition, a 1/v activator such as cobalt, dysprosium, or indium is incorporated in the glass to measure the fluence ($n\bar{v}t$). Following activation over a measured time interval, the absolute source strength of a Co bead is determined by γ-γ coincidence. The flux is directly proportional to the gamma ray source strength. The Dy and In beads are calibrated relative to a Co bead.

9436. **Collagen aggregation phenomena,** J. M. Cassel, *Biopolymers* **4,** 989-997 (1966).

Key words: Collagen; end-to-end bonding; hydrophobic bonding; lateral aggregation; native aggregation; temperature coefficient.

Three processes by which tropocollagen units associate to yield highly specific aggregates have been examined. From the temperature coefficients of the amounts aggregated it is concluded that the complex "native" aggregation is endothermic whereas both end-to-end and lateral aggregation are exothermic. These results combined with additional information lead to the conclusion that "native" aggregation is an entropy driven process in which hydrophobic bonding plays the dominant role. In contrast the reactions producing the lateral aggregate and the aggregate in which end-to-end bonding is dominant are electrostatically governed.

9437. **Glass research at the National Bureau of Standards,** G. W. Cleek, *Glass Ind.* **47,** No. 12, 663-669 (Dec. 1966).

Key words: Glass research; glass technology; properties of glass.

A general account of the research and development in glass technology at the National Bureau of Standards is presented. A brief history of the Bureau's interest in glass is given, followed by a description of the present effort on specific projects in the Inorganic Glass Section of the Inorganic Materials Division.

9438. **Effective charge carrier lifetime in silicon p-i-n junction detectors,** J. A. Coleman and L. J. Swartzendruber, (Proc. 10th

Scintillation and Semiconductor Counter Symp., Washington, D.C., Mar. 23-24, 1966), *IEEE Trans. Nucl. Sci.* **NS-13,** No. 3, 240-244 (June 1966).

Key words: Charge carrier lifetime; lithium-compensated silicon; semiconductor nuclear radiation detectors.

An estimate of the effective charge carrier lifetime can be obtained from a determination of the collection efficiency as a function of the transit time for charge carriers produced by incident short-range radiation in a p-i-n junction detector. The results of this method have the advantage of being independent of both the charge carrier mobility and the depletion depth of the detector. Effective lifetimes as low as a few microseconds (τ_e) for electrons produced by natural alpha particles have been observed in several 2 mm thick lithium-compensated silicon detectors operating at room temperature. No significant bias dependent windows which might cause misleading interpretation of the results were observed. Window effects were investigated by measuring the changes in pulse height of detector output signals initiated by natural alpha particles incident on the detectors at angles up to 45 degrees. The electron lifetimes were observed to decrease when the detector was operated at liquid nitrogen temperature. The short effective lifetimes that can occur in lithium-compensated silicon set a lower limit on the field strengths that must be maintained for efficient charge collection in thick p-i-n junction detectors. Effective hole lifetimes can also be obtained using this technique but with the present geometry of lithium-compensated silicon detectors this measurement is more difficult if short-range particles are used. The effects of charge carrier lifetime and amplifier pulse rise and fall times on the observed radiation-induced pulse shapes are discussed.

9439. **Interface kinetics and the stability of the shape of a solid sphere growing from the melt,** S. R. Coriell and R. L. Parker, (Proc. Intern. Conf. Crystal Growth, Boston, Mass., June 20-24, 1966), *Crystal Growth, a Suppl. to J. Phys. Chem. Solids* **J3,** 703-708 (Pergamon Press Inc., New York, N.Y., 1967).

Key words: Crystal growth; diffusion; heat flow; interface; kinetics; morphology; sphere; stability.

The effects of linear interface kinetics and of square law interface kinetics on the stability of the shape of a sphere growing in a diffusion field are investigated theoretically. Slow interface kinetics can greatly enhance the stability, by several orders of magnitude in certain cases. The sphere can be stable even if its surface energy is zero. Numerical estimates are made for salol and for tin.

9440. **The ionization constant of deuterium oxide from 5 to 50°,** A. K. Covington, R. A. Robinson, and R. G. Bates, *J. Phys. Chem.* **70,** 3820-3824 (1966).

Key words: Deuterium oxide; heavy water; ionization constant; isotope effects.

Electromotive force measurements of a cell without liquid junction have been used to determine the ionization constant of deuterium oxide from 5 to 50°. The value found for pK at 25° is 14.955 (molality scale), 14.869 (molarity scale), and 16.653 (mole fraction scale). Enthalpy, entropy, and heat capacity changes for the dissociation process have been evaluated.

9441. **Mechanical relaxation in polychlorotrifluoroethylene,** J. M. Crissman and E. Passaglia, *J. Polymer Sci.* Pt. C, No. 14, 237-245 (1966).

Key words: Apparatus; isothermally crystallized sample; loss compliance; loss modulus; mechanical relaxation; polychlorotrifluoroethylene; quenched sample; storage modulus; tan δ; torsion pendulum; varying crystallinities.

Measurements of the viscoelastic functions Δ, G', G'', J', and J'' as functions of temperature from -180 to $+180$ °C have been obtained, using a torsion pendulum apparatus, for several samples of polychlorotrifluoroethylene having widely different crystallinities as determined by density. The low crystallinity samples show two relaxations: a very broad one (γ) centered at about -35 °C which appears to be split into two processes, and one (β) at 84 °C. In the higher crystallinity samples, a third process (α) appears at about 137 °C, and the high temperature side of the γ relaxation peak is lower in magnitude as compared to the lower crystallinity specimens. For the β peak, which is assumed to be associated with the glass transition, the peak value for G'' is essentially independent of crystallinity, while both Δ and J'' show decreases in magnitude with increasing crystallinity. The relationship between the magnitude of the relaxation peak and crystallinity, and dependence of this relationship upon the viscoelastic function chosen to characterize the relaxation are discussed.

9442. **Soft X-ray spectrum of Ni and comparison with photoemission and ion neutralization results,** J. R. Cuthill, A. J. McAlister, and M. L. Williams, *Phys. Rev. Letters* **16,** No. 22, 993-995 (May 30, 1966).

Key words: Ag; Cu; double electron photoexcitation; Ni; photoemission; soft X-ray spectrum.

The soft X-ray $M_{2,3}$ spectrum of Ni has been observed, and new features found. The spectrum agrees well with ion neutralization results on Ni, but disagrees sharply with the density of states deduced from the photoemission spectrum of Ni. A double electron photoexcitation process which removes this discrepancy is suggested and shown to fit the available photoemission data on Ni and Cu and Ag as well.

9443. **Molecular emission spectra in the soft x-ray region,** R. D. Deslattes and R. E. LaVilla, *Appl. Opt.* **6,** No. 1, 39-42 (Jan. 25, 1967).

Key words: Molecular energy levels; molecules; x-ray spectra.

Spectra from several chlorine-containing hydrocarbon molecules excited to x-ray fluorescence have been recorded by a double crystal spectrometer with high resolving power. This study focuses on the region near the occurrence of the transition $\rightarrow\beta_{1,3}(1s^{-1}\kappa 3p^{-1})$ in chlorine. Whereas the free atom spectrum (from a single vacancy process) consists of an unresolved spin-orbit doublet, e.g., in argon, the molecular spectra often contain several lines. In free atom spectra and in molecular spectra also, there are extra lines or unresolved multiplets (satellites) due to multiple vacancy processes. In this report, these satellite lines are experimentally sorted out of the spectra and the remaining emission peaks associated with possible final state configuration containing a vacancy, i.e., the electronic terms of the molecule.

9444. **Mossbauer spectrometry,** J. R. DeVoe and J. J. Spijkerman, *Anal. Chem.* **38,** 382R-393R (1966).

Key words: Chemical structure analysis; Mossbauer spectroscopy.

A review of the applications of Mossbauer spectroscopy to chemical analysis, and a bibliography of publications on these applications in 1965 are presented. The principle of the spectrometer as well as a discussion of errors associated with its use are described. Current theoretical interpretation of some aspects of the Mossbauer spectrum are discussed. Chemical structure analysis is the most prevalent application to date, and other applications, such as metallurgy and quantitative analysis appear to be promising.

9445. **Some relations for straight dislocation,** R. deWit, *Phys. Stat. Sol.* **20,** 567-573 (1967).

Key words: Continuum; crystal; defect; dislocation; displacement; interaction; isotropic; strain; stress.

Expressions are presented for the stress, strain, dilatation, and displacement due to a straight dislocation, as well as the force per unit length and the total force on a straight dislocation due to another straight dislocation. They differ from previous expressions in the literature in that they are given completely in tensor or vector notation. They are limited to the case of a *linear, isotropic, infinite* continuum.

9446. **The self-energy of dislocation configurations made up of straight segments,** R. deWit, *Phys. Stat. Sol.* **20,** 575-580 (Mar. 1967).

Key words: Continuum; crystal; defect; dislocation; energy; interaction; isotropic; straight.

Three general expressions are presented: the first is the interaction energy between two non-parallel straight dislocation segments, the second is the interaction energy between two parallel straight segments, and the third is the self-energy of a straight segment. These can be used to determine the total energy of any dislocation configuration made up of piecewise straight segments. They differ from previous expressions in the literature primarily in that they are given completely in vector notation and in that self-energy includes a core traction term. The expressions are limited to the case of a *linear, isotropic, infinite* continuum. As an example, the formulas are applied to the case of a stacking-fault tetrahedron.

9447. **Anomaly in Young's modulus and internal friction of $5SrTiO_3 \cdot 3La_{2/3}TiO_3$ below 100 °C,** R. W. Dickson, *J. Am. Ceram. Soc.* **49,** No. 11, 628 (Nov. 1966).

Key words: Internal friction; lanthanum titanate; phase change; resonance; strontium titanate; vacancies; Young's modulus.

A rapid decrease in Young's modulus with decreasing temperature suggests that some type of phase change may occur in $5SrTiO_3 \cdot 3La_{2/3}TiO_3$ near 80 °C despite the lack of evidence in x-ray patterns.

9448. **Effects of packing pressures on the properties of spherical alloy amalgams,** G. T. Eden and R. M. Waterstrat, *J. Am. Dental Assoc.* **74,** No. 5, 1024-1029 (Apr. 1967).

Key words: Adaptability; amalgams; dental amalgam; dentistry; mercury-silver alloys; packing pressure; particle size; silver-tin alloys; spherical alloy; spherical-alloy amalgam.

The properties of dental amalgams prepared from spherical-alloy particles are compared with the properties of amalgams prepared from irregularly shaped conventional alloy particles. The spherical-alloy amalgams were found to be as strong or stronger than the conventional amalgams and in addition the spherical alloy amalgams possess a superior property of "adapting" their shape to that of the cavity walls particularly when they are condensed under low packing pressure. The spherical alloy amalgams also are capable of retaining a greater fraction of their strength at low packing pressures where the conventional amalgams lose their strengths rapidly.

The use of spherical-alloy amalgams offers the dentist superior "adaptability" and better control over such variables as rate-of-hardening, setting expansion strength, carvability, mercury content, etc., through a more effective control of alloy particle size and shape.

9449. **A broad-line proton magnetic resonance study of cobalt tetracarbonyl hydride,** T. C. Farrar, F. E. Brinckman, T. D. Coyle, A. Davison, and J. W. Faller, *Inorg. Chem.* **6,** No. 1, 161-163 (Jan. 1967).

Key words: Bond length; broad-line; carbonyl; cobalt; cobalt tetracarbonyl hydride; hydride; nuclear magnetic resonance; proton.

The broad-line proton magnetic resonance spectrum of cobalt tetracarbonyl hydride, $HCo(CO)_4$, has been measured. The Co-H bond distance is determined to be 1.2 Å with an estimated overall uncertainty of ±0.1 Å. The use of the n.m.r. method for structural investigation of polycrystalline solids is discussed.

9450. **Proton broad-line n.m.r. study of [$^2H_6$]dimethoxy[^{11}B]borane,** T. C. Farrar, J. Cooper, and T. D. Coyle, *Chem. Commun.* **17,** 610-611 (1966).

Key words: Bond lengths; boron; broad-line; dimethoxyborane; hydride; nuclear magnetic resonance; proton.

The broad-line proton magnetic resonance spectrum of polycrystalline $H^{11}B(OCD_3)_2$ has been measured at 29.95 MHz from the melting point to −180 °C. The spectrum shows well-resolved fine structure arising from intramolecular dipolar coupling of the hydridic hydrogen with the ^{11}B nucleus. The boron-hydrogen distance is determined to be 1.25 Å with a standard deviation of 0.05 Å.

9451. **Initial kinetic parameters from thermogravimetric rate and conversion data,** J. H. Flynn and L. A. Wall, *J. Polymer Sci. Letters* **5B,** No. 2, 191-196 (Feb. 1967).

Key words: Energy of activation; initial kinetic parameters; non-isothermal kinetics; polyethylene; polymer degradation; stability of polymers; thermogravimetry.

A new method for determining the initial activation energy for a volatilization process is developed from the limiting characteristics of rate versus conversion plots and a few simple variants thereof. At low conversion, the energy of activation of linear polyethylene was $E(0.003<C<0.025;\ 630\ °K<T<680\ °K) \cong 36$ kcal/mol, while a sample preheated at 200 °C in a vacuum for an hour gave $E(0.003<C<0.04;\ 640\ °K<T<685\ °K) \cong 60$ kcal/mol.

9452. **Development of performance standards,** B. E. Foster, *Military Engr.* **58,** No. 385, 335-336 (Sept.-Oct. 1966).

Key words: Accelerated tests; bathtubs; external wall units; innovation; long-time behavior; performance standards.

The performance concept in building has been the subject of a great deal of discussion and study during the past several years. When applied to materials and components, difficulties arise in devising performance-type tests which will predict the probable life expectancy in a particular environment or application. A brief discussion of two projects undertaken by the Building Research Division of the National Bureau of Standards, one on external wall units and the other on bathtubs, in which important performance elements were identified, and performance-type tests recommended for all properties except those of anticipated long-time behavior illustrates the problem. The general present lack of satisfactory accelerated test procedures will require that for some time to come performance-type tests must be supplemented by technical judgement rendered by experts experienced in the properties of materials and their probable interactions.

9453. **Magnetic susceptibility of insulating and semiconducting strontium titanate,** H. P. R. Frederikse and G. A. Candela, *Phys. Rev.* **147,** No. 2, 583-584 (July 15, 1966).

Key words: Bandstructure; insulator; magnetic susceptibility; Pauli paramagnetism; semiconductor; strontium titanate.

The magnetic susceptibility of strontium titanate with and without charge carriers has been measured at 300, 78, and 4.2 °K. Insulating $SrTiO_3$ shows a magnetic moment, which is partly diamagnetic and partly (Van Vleck) paramagnetic. The free-carrier contribution is mainly paramagnetic because of the high density of states. As the concentration of carriers is increased the temperature dependence disappears. At the highest concentration ($\sim 6 \times 10^{20}$/cc), pure Pauli paramagnetism is observed. The density-of-states effective mass at the bottom of the conduction band deduced from these measurements is $5m_0$, in good agreement with values from transport experiments.

9454. **Nucleation in polymers,** F. Gornick and J. D. Hoffman, *Ind. Engr. Chem.* **58,** No. 2, 41-53 (Feb. 1966).

Key words: Chain folding; crystal growth; crystallization kinetics; homogeneous nucleation; interfacial energy; nucleation; polychlorotrifluoroethylene; polyethylene; polymers; surface free energy.

This article is a review of current theories and experimental data on homogeneous nucleation and crystal growth with chain folding in linear polymers.

9455. **Determination of glycerol in paper,** E. L. Graminski and B. W. Forshee, *Tappi* **49,** No. 7, 324-326 (July 1966).

Key words: Animal glue; glucose; glycerol; mannitol; melamine resin; paper; sucrose.

Glycerol in paper can be determined by extraction with water and oxidation with sodium periodate in a slightly acidic medium. The formic acid produced during the oxidation is a measure of the glycerol present. Polyhydroxy alcohols and sugars having three or more adjacent hydroxy groups also produce formic acid when oxidized with periodate. The presence of these materials can be ascertained by determining the molar ratio of periodate consumed to the formic acid produced. If the molar ratio is less than 2:1 or the formic acid produced after a 60-minute oxidation is significantly higher than that produced after five minutes, interfering material is present. Information concerning the chemical nature of the interfering material may be obtained from the change in periodate/formic acid ratio between 5- and 60-minute oxidations.

9456. **Inversion temperatures and pressures for cryogenic gases and their mixtures,** R. D. Gunn, P. L. Chueh, and J. M. Prausnitz, *Cryogenics* **6,** No. 6, 324-329 (Dec. 1966).

Key words: Corresponding states; cryogenic gases; generalized inversion curve; Joule-Thomson coefficient; mixtures.

A generalized Joule-Thomson inversion curve has been obtained from volumetric data for gases with acentric factors less than 0.10. The curve is plotted in coordinates of reduced pressure and reduced temperature and a deviation function is provided for gases which, because of quantum effects, do not conform to classical corresponding states behavior. Semi-empirical mixing rules are recommended for calculating the inversion curve of gas mixtures. For two binary systems (hydrogen-methane and helium-nitrogen) it was found that at constant temperature, a plot of inversion pressure versus mole fraction goes through a strong maximum. Calculated results for mixtures compare favorably with the very limited experimental data now available.

9457. **The nucleation of Hg on W as observed by field-emission microscopy,** S. C. Hardy, (Proc. Intern. Conf. Crystal Growth, Boston, Mass., June 20-24, 1966), *Crystal Growth, a Suppl. to J. Phys. Chem. Solids* **C13,** 287-293 (Pergamon Press Inc., New York, N.Y., 1967).

Key words: Electron field emission; Hg on W; nucleation.

The nucleation of Hg from the vapor onto W has been studied under ultra-high-vacuum conditions in a field-emission microscope. A critical supersaturation for formation of nuclei is measured from 184 °K to 240 °K. Below 210 °K, the temperature dependence of the critical supersaturation data is found to fit the model of disc-shaped critical nuclei with no entropy of mixing contribution to their free energy of formation. At higher temperatures, the data indicate that nucleation occurs by the impingement of subcritical clusters.

9458. **Avalanche radiation from the bulk of long, thin, forward-biased p^+-p-n^+ silicon diodes,** G. G. Harman, *Appl. Phys. Letters* **9,** No. 5, 207-209 (Sept. 1, 1966).

Key words: Hot electrons; silicon diodes; visible radiation.

Avalanche radiation has been observed from the bulk of long, thin, forward-biased p^+-p-n^+ silicon diodes with applied field strengths as low as 1000 V/cm. At higher fields, surface arc erosion streaks occurred and these followed crystallographic plane directions rather than the applied field orientation. Possible explanations are given for the several effects that contribute to the observed phenomena.

9459. **Estimate of extrinsic stacking-fault energies from dislocation configurations,** W. F. Hartl, R. deWit, and R. E. Howard, *J. Appl. Phys.* **38,** No. 1, 1-4 (Jan. 1967).

Key words: Dislocations; extrinsic faults; silver-tin alloy; stacking fault energy.

In this paper we use straight-line models of observed extrinsic nodes to estimate extrinsic stacking-fault energies. Using isotropic elasticity theory and neglecting interactions, we find simple expressions for the energy in terms of the inscribed radii of the nodes. We apply the results to observed extended nodes in silver-8 at.% tin alloy and find a ratio of extrinsic to intrinsic stacking-fault energy of about 3.

9460. **Dissociation constant of morpholinium ion and related thermodynamic quantities from 0 to 50°,** H. B. Hetzer, R. G. Bates, and R. A. Robinson, *J. Phys. Chem.* **70,** No. 9, 2869-2872 (Sept. 1966).

Key words: Bases; dissociation constant; emf measurements; morpholine; morpholinium ion; thermodynamic quantities.

The thermodynamic dissociation constant of morpholinium ion (MH^+) at 11 temperatures from 0 to 50° has been determined from emf measurements of hydrogen-silver chloride cells without liquid junction. The dissociation constant (K_a) for the process $MH^+ + H_2O \rightleftharpoons M + H_3O^+$ is given as a function of T(°K) by the equation $-\log K_a = 1663.29/T + 4.1724 - 0.0042239T$. At 25°, $-\log K_a$ is 8.492, $\Delta H°$ is 39,030 joules mole^{-1}, $\Delta S°$ is -31.7 joules deg^{-1} mole^{-1}, and $\Delta C_p°$ is 48 joules deg^{-1} mole^{-1}.

9461. **Solid-vapor equilibrium in the system neon-methane,** M. J. Hiza and A. J. Kidnay, *Cryogenics* **6,** No. 6, 348-354 (Dec. 1966).

Key words: Low-temperature phase-equilibrium; methane; minimum gas phase equilibrium concentration; neon; neon-methane binary system; solid-vapor equilibrium.

Gas phase compositions in the solid-vapor region for the neon-methane system were measured at eight integral temperatures from 50 to 87 °K up to 100 atmospheres pressure. A flow system was used in which methane was evaporated into a stream of pure neon gas. The equilibrium methane content of the gas phase leaving the equilibrium cell was analyzed continuously with a hydrogen flame-ionization detector. A comparison of these data at 76 °K with data for the hydrogen-methane and helium-methane systems is made to show the relative non-ideality of the neon system. Theoretical calculations of the concentration minima for this system are in poor agreement with experimental values.

9462. **Analysis of the α, β, and γ relaxations in polychlorotrifluoroethylene and polyethylene: dielectric and**

mechanical properties, J. D. Hoffman, G. Williams, and E. Passaglia, *J. Polymer Sci.* Pt. C, No. 14, 173-235 (1966).

Key words: Annealing; chain fold; chain rotation; chain twisting; defect; dielectric relaxation; mechanical relaxation; polychlorotrifluoroethylene; polyethylene; polymer: semicrystalline; vacancy.

Theoretical models for the α_c and γ_c relaxation effects found in chain-folded polymer crystals (single crystal mats and bulk) are presented, and compared with the available dielectric and mechanical loss data for polyethylene and polychlorotrifluoroethylene. Details of morphology and crystal structure that can be varied by crystallization and annealing procedures, e.g., roughness of chain-folded surfaces, number of intercrystalline links and cilia, number of chain-end defects and dislocations, and the existence of the extended-chain phase, are brought into the discussion. The α_c process, which consists of two overlapping mechanisms, is a result of motions of chain folds, and reorientation (with translation) of chains in the interior. (Chain twisting also occurs for long chains. The theory connects the data on the *n*-paraffins and their polar derivatives (n-ketones, esters, ethers) with the results on polymers: the common feature is the chain reorientation and twisting process. A new theory of chain twisting is introduced. The γ_c relaxation is a result of reorientation of chains in a "loose" chain-end induced defect (a vacancy row) in the polymer crystal. When the effect of chain twisting is included, the theory successfully predicts the unusually broad and asymmetric loss curve found in the polymer, and is consistent with experimental activation energies.

The β relaxation arising in the amorphous component of PCTFE is analyzed, and its upward shift in temperature with increasing crystallinity discussed in terms of the Adam-Gibbs theory of relaxation in the glassy state. The γ_a amorphous relaxation, and the δ relaxation which is found at cryogenic temperatures, are also discussed.

9463. **Condensation of dry air on a liquid hydrogen cooled surface in the pressure range 10^{-3} to 10 torr (Knudsen number of 10^{-4} to 1),** J. Hord, *Cryogenics* 6, No. 5, 285-293 (Oct. 1966).

Key words: Air collector; air condensation; air sampling; air solidification at 20 °K; cryodeposit; cryodeposit surface temperature; cryopumping; cryopumping air at 20 °K in the transition pressure regime; geysering; heat transfer to air condensing at 20 °K.

The rate of condensation of dry air on a liquid hydrogen cooled surface has been determined experimentally and compared with analytical predictions. Free molecule flow theory appears adequate for high conductance systems at bulk air pressures up to 10^{-1} torr. At higher pressures this formulation predicts condensation rates which are too large. Continuum bulk flow theory and free molecule flow theory agree fairly well throughout the pressure range investigated; however, bulk theory is more compatible with experiment. Theoretical and experimental condensation rates are presented as a function of air bulk pressure and cryodeposit (solid air frost) surface temperature. Surging (slug flow) of static liquid hydrogen refrigerant inside small bore tubes was experimentally observed and is presented as a function of heat flux. The liquid hydrogen was vented to the atmosphere from a tube designed to provide 0.33 g acceleration along the tube axis.

9464. **Kinetics of solute-enhanced diffusion in dilute face-centered-cubic alloys,** R. E. Howard and J. R. Manning, *Phys. Rev.* **154,** No. 3, 561-568 (Feb. 1967).

Key words: Correlation factors; diffusion; dilute alloys; impurities; jump frequencies; solute atoms; vacancies.

A theory of the effect of solutes on solvent self-diffusion in dilute f.c.c. alloys is given based on the model of nearest-neighbor interactions between solute impurities and vacancies. The parameters of the theory are the four vacancy jump frequencies in the neighborhood of an impurity and the vacancy jump frequency in the pure crystal. No assumptions are made about the relative magnitudes of these frequencies. This distinguishes the present theory from previous theories based on the same model. The theory is used to deduce for each of nine dilute Ag-based alloys sets of jump frequency ratios (and corresponding impurity correlation factors) that are consistent with measured values of the solute enhancement coefficient and of the impurity diffusion coefficient. The desirability of isotope effect measurements to determine the impurity correlation factors is emphasized.

9465. **Moisture permeation of leather and plastics used in shoes,** J. R. Kanagy, *J. Am. Leather Chemists' Assoc. Tech. Note* **LXII,** No. 2, 115-122 (Feb. 1967).

Key words: Absorption, water; adsorption, water vapor; leather; permeation; water vapor permeability.

Data are given on moisture permeation of leather and plastics exposed both to water and water vapor. The rate of moisture permeation of some plastics is equivalent to that of some leather now used. The permeation of moisture through leather depends upon the tannage, and by adopting the proper tannage could be greatly increased. However, leathers that are highly permeable to water are not practical for use in shoes, and in this respect man-made materials will undoubtedly be able to compete with leather. Other properties, such as insulation and ability to mold to the feet, are characteristics which will continue to make leather a preferred material for shoes.

9466. **Note on the variation of the results of the Mullen burst test over the area of a hide,** J. R. Kanagy, *J. Am. Leather Chemists' Assoc. Tech. Note* **LXII,** No. 1, 63-67 (Jan. 1967).

Key words: Burst of leather; extension; grain-crack; Mullen test.

Variation of the Mullen test results was determined over hide by cutting the entire area into 3 by 3 inch pieces and testing each of the specimens. Percentage stretch with increase in load was determined, and the point at which grain-crack occurred was noted. Grain-crack is prevalent in specimens from locations on the butt of the hide. In this position stretch increases rapidly with load because of the physical structure of the fibers. Ninety percent of the specimens which cracked were from the small area of the butt which constituted three to four square feet. The other areas of a full-grown cattle hide were almost entirely free of grain-crack when subjected to 600 pounds in the Mullen tester.

9467. **Optical power increase in GaAs laser diodes coated with reflecting aluminum silicone mixture,** H. K. Kessler, *Proc. IEEE Letter* **55,** No. 1, 99-100 (Jan. 1967).

Key words: Aluminum-silicone compound; GaAs lasers; heat sink; optical power.

GaAs laser output power has been increased by using the reflectance of an aluminum-silicone mixture coated on a laser diode. After such application, the light output increased from one side by 50 percent, and better heat dissipation from the diode was observed.

9468. **Surface aspects of the thermal degradation of GaAs *p-n* junction lasers and tunnel diodes,** H. Kessler and N. N. Winogradoff, *IEEE Trans. Electron. Devices* **Ed-13,** No. 10, 688-691 (Oct. 1966).

Key words: Degradation; gallium arsenide; lasers; light emission; surface effects; tunnel diodes.

Owing to the similarity of the junction widths and doping levels in epitaxially formed GaAs lasers and conventional tunnel diodes, the gradual degradation of the latter under use might be expected to be intensified in the case of lasers operating under high duty cycle or CW conditions.

It was found that the current-voltage characteristics of both the lasers and tunnel diodes underwent considerable thermal degradation even when no bias was applied, and that the degradation was limited to *surface* or "junction edge" effects.

The degradation of the current-voltage characteristic was correlated with degradation in the light output under forward bias. It was concluded that degradation under forward bias was also a surface effect induced by heating rather than by deterioration of the junction in the bulk, as commonly believed. Methods of controlling the degradations are discussed.

9469. **Ellipsometric-potentiostatic studies of iron passivity. I. Anodic film growth in slightly basic solutions,** J. Kruger and J. P. Calvert, *J. Electrochem. Soc.* **114,** No. 1, 43-49 (Jan. 1967).

Key words: Anodic oxidation; ellipsometry; iron; iron oxide films; kinetics; passivity; potentiostat.

Cathodically reduced iron was anodically oxidized at potentials in the passive region of the anodic polarization curve in slightly basic sodium borate-boric acid solutions by means of a potentiostat. The kinetics of film growth were studied using an ellipsometer coupled with a fast recording technique, which enabled a determination of the rate of film formation for times less than 1 sec. This study of the kinetics of film growth using a nonelectrochemical technique agreed with kinetic results based on total charge measurements. Three stages of growth were detected: (1) First stage — growth limited by a diffusion process in the solution; (2) Second stage — start of limitation of growth by the film involving the combination of several processes difficult to characterize by any rate law; (3) Third stage — growth obeying either a logarithmic or inverse logarithmic rate law. The latter was found to imply that the passive film consisted of an outer layer poorly conductive for electrons.

9470. **Pyroelectric effect in bone and tendon,** S. B. Lang, *Nature* **212,** No. 5063, 704-705 (Nov. 12, 1966).

Key words: Bone; collagen; hydroxyapatite; piezoelectricity; pyroelectricity; tendon.

The pyroelectric coefficients (at constant stress) of one of the phalanges, the femur, and the hoof tendon of a cow were measured. The coefficients, which ranged from 2.5 to 4.1×10^{-13} coulomb cm^{-2} $°\mathrm{C}^{-1}$ over the temperature span, −35 to 60 °C, were the smallest yet measured in any material. The results indicate that the collagen of bone and tendon is responsible for both the piezoelectric and pyroelectric effects. The pyroelectric effect in bone and tendon is probably too small to be of physiological significance.

9471. **Remote positioner for rotary switches,** S. B. Lang and A. M. Gray, *Rev. Sci. Instr.* **37,** No. 6, 799-801 (June 1966).

Key words: Remote positioner; rotary switches; vibrating-reed electrometer.

A remote positioner for rotary switches was designed for use on a vibrating-reed electrometer to provide automatic range switching between two preselected levels. The positioner consisted of a bi-directional rotary solenoid motor, driven by a capacitor pulse-counter circuit (diode pump), and was controlled by three rotary switch decks. The positioner was mounted external to the electrometer. The positioner can be used for automatic range switching on many types of electronic apparatus.

9472. **Kinetics of growth of multicomponent chains,** J. I. Lauritzen, Jr., E. A. DiMarzio, and E. Passaglia, *J. Chem. Phys.* **45,** No. 12, 4444-4454 (Dec. 15, 1966).

Key words: Composition; growth rate; kinetics; multicomponent; steady-state.

A theory is presented by which the rate of growth and composition (including all pair and higher distributions) of a chain growing in a multicomponent system may be calculated. Each position in the chain may be occupied by any of the components of the system. Only nearest-neighbor interactions are assumed and the rate constants α^{ij} for addition of Species *j* to a chain ending in Species *i*, and β^{ij}, for the removal of Species *j* from a chain ending in *i,j* are assumed known and independent of chain length, except for those referring to the first step of the chain, which are distinct. The full kinetic equations for the growth of such chains are formulated and a solution obtained for steady-state conditions. It is shown that when the matrix of α^{ij}/β^{ij} is indecomposable and primitive a solution of the equations which is independent of chain length always exists for sufficiently long chains and computational methods for obtaining this solution for a relatively large number of components (of the order of 10) are presented. In addition, the relationship of α^{ij}/β^{ij} to the energetics of the system is derived.

9473. **Chlorine Kβ x-ray emission spectra from several chlorinated hydrocarbon and fluorocarbon molecular gases,** R. E. LaVilla and R. D. Deslattes, *J. Chem. Phys.* **45,** No. 9, 3446-3448 (Nov. 1, 1966).

Key words: Chlorinated molecular gases; chlorine; Kβ x-ray emission.

Emission profiles have been obtained in x-ray fluorescence for the four chlorinated derivatives of methane (CH_3Cl, CH_2Cl_2, $CHCl_3$, CCl_4), and five chlorinated fluoromethanes (CF_3Cl, CF_2Cl_2, $CFCl_3$, $CHFCl_2$, CHF_2Cl) in the gas phase. The chloromethanes contain two prominent lines whereas the chlorofluoromethanes have multiplet structures up to four lines. These structures are interpreted in terms of the molecular orbital determined final state hole energies.

9474. **Electronic data processing in urban tranportation planning,** B. M. Levin and R. E. Schoefer, (Proc. Second Annual Conference on Applications of E.D.P. Systems for State and Local Government, Apr. 1-2, 1966, New York, N.Y.), *Book, The Large-Scale Public E.D.P. System: Its Problems and Prospects,* pp. 169-177 (University of New York, N.Y., 1966).

Key words: Data processing; systems analysis; transportation planning; urban transportation.

The goal of urban transportation planning is to develop a plan for an efficient, balanced transportation system for an urban area — one which will promote a desirable pattern of human activities. While the process has been standardized to some extent, each study must nevertheless acquire and manage a massive amount of information about the particular region with which it is concerned. From this information, models which can be used to predict future land use patterns, travel demands, and the workings of the transportation system are developed and calibrated. Using computerized versions of these models, transportation planners have the capability to propose and test a large variety of future transportation systems, so that one which is well-suited to the future needs of the urban area can be found.

9475. **Structural interpretation of immiscibility in oxide systems. IV. Occurrence, extent, and temperature of the monotectic,** E. M. Levin, *J. Am. Ceram. Soc.* **50,** No. 1, 29-38 (Jan. 1967).

Key words: Borates; glassformers; immiscibility; liquid immiscibility; modifiers, network; oxide systems; silicates.

Liquid immiscibility data in known binary oxide systems are analyzed in relation to three fundamental aspects. Occurrence of immiscibility in glassforming systems is related to differences in ionic field strengths or electrostatic bond strengths between the network cation with oxygen and the modifier cation with oxygen. If this difference is either too small or too large, immiscibility will not be present. Analysis also indicates that immiscibility is not to be expected in binary phosphate and vanadia systems. Factors governing the extent of immiscibility are essentially unrelated to its occurrence; and in borate and silicate systems, immiscibility is inversely correlated with the number of oxygens per modifier cation in the modifier rich liquid. Temperature of the monotectic almost always lies between the melting point of the glassformer and the first compound beyond the immiscibility gap. Properties of the monotectic, such as, the primary phase under the two liquids and location of the eutectic, are fixed according to whether the monotectic temperature is above or below the m. pt. of the glassformer. Principles of immiscibility are summarized.

9476. **The system Sc_2O_3-B_2O_3,** E. M. Levin, *J. Am. Ceram. Soc.* **50,** No. 1, 53-54 (Jan. 1967).

Key words: Boric oxide; liquid immiscibility; oxide systems; phase diagram; scandium oxide.

The phase diagram of the system Sc_2O_3-B_2O_3 has been determined experimentally, by the "quenching" technique. The system is characterized by a single binary compound, $ScBO_3$, melting congruently at 1610 °C and by a region of liquid immiscibility extending at 1526 °C from almost pure B_2O_3 to 34.0 mol.% Sc_2O_3. Immiscibility from qualitative and quantitative standpoints is consistent with the previously elucidated structural interpretation of immiscibility.

9477. **Analysis of lanolin in soap,** F. J. Linnig, *Soap Chem. Specialties* XVLL, No. 7, 55-57 (July 1966).

Key words: Borax; ion-exchange resin; lanolin, soap.

A new method has been developed for the determination of lanolin in lanolin-borax-soap mixtures. A mixed cation-anion exchange resin is used to remove the soap and borax from an aqueous solution of the whole sample. The resin is separated by filtration and washed with an organic solvent to remove lanolin. The solvents are evaporated, and the residue weighed as lanolin. This procedure is simpler and more rapid than the present method, and should be more accurate.

9478. **Embrittlement of high strength AISI 4340 steel in boiling NaCl solution,** H. L. Logan and J. M. Wehrung, *Corrosion* **22,** No. 9, 265-269 (Sept. 1966).

Key words: Boiling sodium chloride solution; delayed failure; high strength steel; hydrogen diffusion; hydrogen embrittlement; internal initiation; stress corrosion.

The resistance of high strength AISI 4340 steel tubing, quenched in oil and tempered to 425 °F, to corrosive media has been investigated. The exterior surface of the specimen was exposed to boiling NaCl, the interior cavity was evacuated, and the specimen was subjected to a tensile stress. Specimens failed, with little evidence that cracking was developing, after several hours exposure and after hydrogen had penetrated through the specimen wall. The appearance of the initial fracture and its mode of development indicate that it originated within the specimen wall. The data indicate that failure resulted from hydrogen embrittlement.

9479. **Stress-corrosion cracking of cold-reduced austenitic stainless steels,** H. L. Logan and M. J. McBee, *Mater. Res. Std.* 7, No. 4, 137-145 (Apr. 1967).

Key words: Atmospheric corrosion tests; chemical attack; cold working; corrosion; cracking; stainless steels; steels; stress corrosion.

The effects of specimen orientation with respect to the direction of rolling or prior rolling on the susceptibility to stress-corrosion cracking in a boiling $MgCl_2$ solution were determined for both annealed and cold-reduced types 301, 304, 310, and 321 stainless steels. Threshold stresses for the most susceptible orientations were determined in a boiling 0.5 *N* NaCl, 0.1 *N* $NaNO_2$ solution to be 60 to 110 percent of the yield strengths of the materials. None of the steels cracked in a marine atmosphere during 15 months' exposure stressed at 90 percent of their yield strengths. The effects on the threshold stresses of varying amounts of cold work differed from steel to steel and are reported. The effects of internal stress patterns and welding were also investigated for some of these steels and are described.

9480. **Phase relations between Cr_2O_3 and IrO_2 in air,** C. L. McDaniel and S. J. Schneider, *J. Am. Ceram. Soc.* **49,** No. 5, 285-286 (May 1966).

Key words: Cr_2O_3-IrO_2 system; dissociation; phase relations; platinum metal oxides; solid solution.

A study has been made by X-ray diffraction analysis of the reactions that occur in an air environment between Cr_2O_3 and Ir or IrO_2. In air Ir oxidizes at low temperatures to form IrO_2 which in turn dissociates at 1020 °C. The pseudobinary system Cr_2O_3-IrO_2 contains a quasi-solid solution region existing from 100 mole % IrO_2 to approximately 21 mole % Cr_2O_3 with a maximum dissociation temperature at 1040 °C. Up to at least 2100 °C no reaction occurred between Cr_2O_3 and Ir.

9481. **Emission spectrometry,** M. Margoshes and B. F. Scribner, *Anal. Chem.* **38,** No. 5, 297R-310R (Apr. 1966).

Key words: Atomic absorption spectrometry; atomic emission spectrometry; atomic fluorescence spectrometry; flame photometry; spectroscopy.

The literature of analytical interest in atomic emission spectrometry, flame photometry, and atomic absorption spectrometry is reviewed for the years 1964-65. The topics included are books and reviews, spectral descriptions and classifications, instrumentation, excitation, standards, calibration, and analytical applications. Literature citations total 351.

9482. **Chemical substructure searching with linear notations,** B. A. Marron, G. R. Boltosky, and S. J. Tauber, *J. Chem. Doc.* **6,** 92-95 (May 1966).

Key words: Chemical; computers; Hayward notation; information retrieval; linear notation; structures; substructure searches.

An experimental computer system was developed that performs chemical structure and substructure searches directly on linear notations.

9483. **Comments on "Nature of the critical nucleus in heterogeneous vapor-solid nucleation",** A. J. Melmed and S. C. Hardy, *Surface Sci.* **6,** No. 4, 481-482 (April 1967).

Key words: Critical nucleus; field-electron emission microscopy; heterogeneous nucleation; vapor deposition.

It is shown that a recent field-electron-emission microscope experiment was significantly misinterpreted and that, therefore, the conclusions cannot be considered meaningful.

9484. **The structure of field-evaporated hexagonal close-packed metal surfaces: rhenium and ruthenium,** A. J. Melmed, *Surface Sci.* **5,** No. 3, 359-379 (Nov. 1966).

Key words: Field evaporation; field ion microscopy; hcp metals; surface structure.

Field-ion micrographs of field-evaporated ruthenium are analyzed and compared with similar micrographs of rhenium.

Certain surface topological features appearing in Ru at 21 °K and 77 °K do not appear in Re at these same temperatures, although the metals are both hcp. The Ru field-evaporated surface clearly develops an exposed A,B,A,B,... sequence, giving half the number of distinguishable net plane edges, in the same crystallographic regions. The difference is discussed in terms of geometric and electronic factors which influence the field evaporation process.

9485. **Determination of the composition of complexes and their instability constant by calorimetry. II. The complex in fused potassium chloride and cadmium chloride,** W. H. Metzger, Jr., A. Brenner, and H. I. Salmon, *J. Electrochem. Soc.* **114,** No. 2, 131-138 (Feb. 1967).

Key words: Calorimeter; calorimetry; complex ion; enthalpy determination; $KCl\text{-}CdCl_2$ system; molten salts.

A new method of determining the composition of complexes in solution and their equilibrium constant has been developed which is based on the determination of the partial molal heat effect developed when a small increment of each salt is added in turn to a series of mixtures covering the whole range of composition. The method was applied to the molten $KCl\text{-}CdCl_2$ system which was shown to contain the 1:1 complex with an instability constant of 0.32 at a temperature of 600 °C and 780 °C. A calorimeter was developed which permitted the addition of the increments of salt to the molten mixture while the latter was continually stirred.

9486. **Analyzing liquid H_2 with NMR,** C. E. Miller, W. J. Alspach, and T. M. Flynn, *Cryogenic Engr. News* **1,** No. 8, 66 (June 1966).

Key words: Analyzer; cryogenics; hydrogen; instrument; instrumentation; liquefier; liquid hydrogen; measurement; nuclear spin relaxation time; ortho-para; relaxation time; T_1.

The nuclear spin relaxation time (T_1) of liquid hydrogen is shown as a function of the ortho-para composition of the fluid. A scheme is suggested whereby an ortho-para analyzer might be made which depends upon this fact. Such an instrument would have fast response, not depend on a reference gas, and be useful under flowing (dynamic) conditions.

9487. **Fracture topography of brittle polymers,** S. B. Newman, *Polymer Engr. Sci.* **5,** No. 3, 159-165 (July 1965).

Key words: Brittle polymers; fracture topography; kinetics; polymeric solids; primary fracture front; topography.

Fracture surfaces record the kinetics of failure at two levels in the structure of polymeric solids. The first is evidenced by the formation of geometric markings resulting from the interaction of the primary fracture front with secondary fractures developing radially just ahead of the primary fracture. These markings are often visible to the unaided eye and have minimal dimensions in the micron range. The second fracture phenomenon appears to involve the orientation of molecular chains or bundles. Such orientation manifests itself in the interference-color producing film found on the fracture surfaces of poly(methylmethacrylate) and polystyrene. It is also apparent in the free or adherent film found on the surfaces of large fractured crazes. Some evidence is presented for the existence in these films of chain bundles 30A or less in diameter. Similar mechanisms are apparently operating in the production of "craze matter" and of fracture surface films.

9488. **Reflection of soft x-rays by organic fibers,** S. B. Newman, *J. Appl. Polymer Sci.* **10,** No. 12, 1929-1935 (1966).

Key words: Fibers; microfocus tubes; microradiography; nylon; polyacrylonitrile; polyamides; reflection of x-rays; soft x-rays; x-rays.

An artifact observed in point projection microradiographs of polymeric fibers and filaments obtained with 8 A x-rays is recorded and described. The phenomenon has been related to fiber-beam geometry and the high reflection efficiency of soft x-rays for these materials.

9489. **Kinetics and statistics of structural changes in polyacrylonitrile,** K. Noh and H. Yu, *J. Polymer Sci. Letters* **4B,** No. 10, 721-726 (Oct. 1966).

Key words: Cyanide groups; initiation; isolation; naphthylidiene ring; polyacrylonitrile; propagation.

The structural changes attending the heat treatment of polyacrylonitrile at 170 °C~220 °C were analyzed on the basis of the naphthylidiene type ring formation. The kinetics of the ring formation was found to be first order with respect to cyanide groups along the polymer chain. About 20% of the cyanide groups remain unreacted irrespective of the heating temperature. The observed first order kinetics is consistent with the statistical analysis of the ring formation mechanism which is well established in the literature.

9490. **Galvanic pitting in metallic coatings,** F. Ogburn and M. Schlissel, *Plating* **54,** No. 1, 54-62 (Jan. 1967).

Key words: Corrosion; corrosion currents; electroplating; galvanic corrosion; pitting; pitting corrosion.

An electrolytic cell is described which simulates a corrosion pit extending through a metal coating and permits measurement of the cell currents. Such cells were used to investigate the galvanic currents between coatings of chromium, copper, and nickel and substrates of zinc, iron, nickel, and copper. The investigation included outdoor salt spray and corrodkote exposures; and determinations of the effects of anode size, depth of electrolyte, and proximity of a second anode on cell currents. An equation for the cell current as a function of the cell parameters is discussed and compared with experiments.

9491. **Flow properties of aqueous suspensions containing kaolins of varying degrees of crystallinity,** W. C. Ormsby and J. H. Marcus, *J. Am. Ceram. Soc.* **50,** No. 4, 190-195 (Apr. 1967).

Key words: Cation exchange capacity; cone-plate viscometer; crystallinity; flow properties; kaolins; surface area.

A study was made of the influence which varying degrees of crystal perfection of several Georgia kaolins had on the flow properties of aqueous systems containing these clays. The fractionated clay samples were characterized with respect to clay mineral composition, crystallinity, surface area, and cation exchange capacity. A recording Ferranti cone-plate viscometer equipped with truncated cones was used to examine the clay-water mixtures under a variety of experimental conditions. Emphasis was placed on high shear-rate measurements of systems of intermediate water content.

A comparison of results for bulk samples and fine particle-size fractions of different clays showed a general qualitative correlation between viscosity (or consistency) and degree of crystallinity. In these samples, which were usually pseudoplastic, the viscosity tended to increase with decrease in crystallinity. Coarse particle-size fractions of the various clays exhibited essentially Newtonian behavior while samples of intermediate particle size and relatively good crystallinity exhibited dilatancy. The extent of dilatancy was usually a function of the degree of crystallinity.

The viscosity of the fine particle-size fractions of a single, well-crystallized clay, which exhibited an apparent increase in crystallinity with decrease in particle size, increased as the particle size decreased. This correlation between viscosity and particle size was also noted for the fine fractions of a poorly crystallized clay in which the crystallinity was essentially independent of the particle size.

In general, results indicated that dilatant and associated properties were controlled by the degree of crystal perfection whereas the viscous and plastic properties, at a given water content, were generally dependent upon the particle size.

9492. **Dissociation of acetic acid-d_4 in deuterium oxide from 5 to 50° and related isotope effects,** M. Paabo, R. G. Bates, and R. A. Robinson, *J. Phys. Chem.* **70,** 2073-2077 (1966).

Key words: Acetic acid-d_4; acid-base; deuterium oxide; dissociation constants; emf; ionization; isotope effects; thermodynamics; weak electrolytes.

The dissociation constant of acetic acid-d_4 (CD_3COOD) in deuterium oxide (D_2O) has been determined by the emf method at ten temperatures from 5 to 50°. From the variation of the dissociation constant with temperature, the changes of enthalpy, entropy, and heat capacity have been derived. The four dissociation processes, namely those for ordinary acetic acid in ordinary water, for deuterioacetic acid in ordinary water, and for these two acids in deuterium oxide, are compared.

9493. **Dissociation of 4-aminopyridinium ion in 50 weight percent methanol—water and related acidity functions from 10° to 40 °C,** M. Paabo, R. A. Robinson, and R. G. Bates, *Anal. Chem.* **38,** No. 11, 1573-1575 (Oct. 1966).

Key words: Acid-base equilibria; aminopyridine; dissociation constant; electrolytic dissociation; methanol-water solvents; thermodynamics.

The dissociation constant of 4-aminopyridinium ion in 50 wt.% methanol-water has been determined by the electromotive force method from 10° to 40 °C. The pK value at 25 °C is 8.520 compared with 9.114 in water. The changes in free energy, enthalpy, and entropy in the dissociation process have been calculated. Values of $p(a_H\gamma_{Cl})$ and pa_H^* are given for buffer solutions containing equimolal amounts of 4-aminopyridine and its hydrochloride.

9494. **Bonding porcelain teeth to acrylic resin denture bases,** G. C. Paffenbarger, W. T. Sweeney, and R. L. Bowen, *J. Am. Dental Assoc.* **74,** 1018-1023 (Apr. 1967).

Key words: Bonding; coupling agent; denture; plastic; porcelain adhesion; resin; silane; teeth.

The chemical bonding of porcelain teeth to both cold- and heat-curing denture bases of acrylic resins was accomplished by the use of a silane coupling agent, gamma-methacryloxypropyltrimethoxysilane. In tension the procelain-resin interface did not rupture—invariably the teeth did. Untreated teeth showed no measurable bonding to the resin. Because of a lack of adhesion between porcelain teeth and acrylic resins the design of most current porcelain teeth provide for mechanical locking using metal pins or undercut wells and canals (diatoric form). These designs weaken the teeth unduly and can be eliminated by the use of a solid tooth which has been treated with an appropriate silane. The bonding strengthens the denture since it makes the effective cross-sectional area greater and prevents seepage between the tooth and the plastic and so aids oral hygiene and esthetics.

9495. **Recent advances in U.S.A. research on dental amalgams and possible applications,** G. C. Paffenbarger, *Intern. Dental J.* **16,** No. 4, 450-465 (Dec. 1966).

Key words: Amalgam; dental; research.

Current research on dental amalgam in the United States is developing information regarding the extrusion of amalgam restorations from cavities; the desirability of low mercury-to-alloy ratios; the design of universal technics for mixing and compacting; the effect of residual mercury content; the relation among compressive, tensile and transverse strengths; the phases present in the hardened amalgam; corrosion; and the advantages of amalgam made from spherical alloy powder.

9496. **Growth of calcium molybdate crystals by a temperature-gradient zone-melting technique,** H. S. Parker and W. S. Brower, (Proc. Intern. Conf. Crystal Growth, Boston, Mass., June 20-24, 1966), *Crystal Growth, a Suppl. to J. Phys. Chem. Solids* **E-12,** 489-491 (Pergamon Press Inc., New York, N.Y., 1967).

Key words: Calcium molybdate; crystal growth; lithium sulfate; single crystals; temperature gradient zone melting; traveling solvent.

Calcium molybdate crystals were grown using the temperature gradient zone melting technique. Lithium sulfate was used as flux and growth temperatures were in the 830-960 °C temperature range. Initial zone thicknesses ranged from about 1.3×10^{-3} cm to 7.0×10^{-2} cm, and regrowths of from 0.4 to 1.2 mm were obtained during heatings of 48-96 hours.

9497. **Galvanic corrosion of metals in cementing materials,** J. W. Pitts, *Military Engr.* **59,** No. 387, 40-41 (Jan.-Feb. 1967).

Key words: Aluminum conduit; calcium chloride; concrete; corrosion in concrete; corrosion in plaster; dissimilar metals; galvanic corrosion; gypsum plaster.

A brief discussion is presented of some corrosion problems that have developed in recent years resulting from the use of dissimilar metals embedded in portland cement concrete and gypsum plaster. It is shown how dissimilar metals embedded in such cementing materials can form short-circuited galvanic cells and how corrosion of the anodes has led to failures of both steel-reinforced concrete containing aluminum conduit and of gypsum plaster-metal lath systems in which copper tubing was embedded. Examples of failures are cited. Some of the variables that affect the degree of corrosion are discussed and some general precautionary measures are recommended.

9498. **Thermal insulation in buildings,** F. J. Powell, *Military Engr.* **58,** No. 38, 275-276 (July-Aug. 1966).

Key words: Indoor thermal environment; insulated construction; insulation research; thermal building design; thermal insulation; thermal performance standards.

The role of thermal insulation in the design of a building is presented from the viewpoint of the engineer. Presently used design procedures and other limitations, environmental and applications factors that influence the performance of a thermal design and some current research problems that involve insulated constructions are discussed. The benefits from the use of thermal insulation and their importance to a nation are given.

9499. **The crystal and molecular structure of dichloro(1,10-phenanthroline)zinc,** C. W. Reimann, S. Block, and A. Perloff, *Inorg. Chem.* **5,** No. 7, 1185-1189 (July 1966).

Key words: Crystal structure; dichloro(1,10-phenanthroline) zinc; molecular structure; tetrahedral.

Crystals of dichloro(1,10-phenanthroline)zinc are monoclinic with four molecules in a unit cell of dimension $a = 9.73$, $b = 15.67$, $c = 7.97$ Å, $\beta = 101° 5'$, space group $P2_1/n$. Three-dimensional data were used, and the structure was solved as a heavy-atom problem. The coordination about the zinc atom is distorted tetrahedral. The 1,10-phenanthroline molecule itself is essentially planar, and the zinc atom departs 0.13 Å from this plane. The chlorine atoms are nearly equidistant from the zinc atom. The plane of the zinc and two chlorine atoms makes an angle of 79° with the plane of the 1,10-phenanthroline molecule.

9500. **Study suggests value of shared computers,** A. E. Rikli, S. I. Allen, and S. N. Alexander, *Mod. Hosp.* **106,** No. 5, 100-108 (May 1966).

Key words: Administration; hospital data communications; laboratory; nursing station; pharmacy; real-time hospital information system; remote data input.

A survey of real-time hospital information systems in advanced stages of development has been made and is reported briefly here. By definition, such a system is one that is in direct communication with portions of the hospital environment by receiving data, processing transactions, and returning results with sufficient responsiveness to affect patient care and administrative decisions near the time of occurrence of medical or hospital events. Eight hospitals qualified under the definition, and the general conclusion to be drawn is that more design studies and experimentation with equipment and techniques are essential to solving the special communications and information problems of hospitals.

9501. **Dislocation node determinations of the stacking-fault energy in silver-tin alloys,** A. W. Ruff, Jr. and L. K. Ives, *Acta. Met.* **15,** 189-198 (Feb. 1967).

Key words: Dislocations; electron microscopy; silver-tin alloy; stacking-fault energy.

Direct measurements by transmission electron microscopy on extended dislocation nodes in alloys of tin in silver have led to values for the intrinsic stacking-fault energy. The values decreased smoothly from 23 erg/cm^2 for pure silver to 4.5 erg/cm^2 for 7.8 at.% tin, near the f.c.c. phase limit. The results are compared with previous determinations in other silver-base alloys, and sources of systematic error are discussed. A comparison of different theoretical analyses is included.

9502. **The stacking-fault energy in α-silver-tin alloys,** A. W. Ruff, Jr. and L. K. Ives, *Canadian J. Phys.* **45,** 787-795 (1967).

Key words: Dislocation nodes; dislocations; electron microscopy; silver-tin alloys; stacking-fault energy; stacking faults.

Direct measurements by transmission electron microscopy on extended dislocation nodes in alloys of tin in silver have led to values for the intrinsic stacking-fault energy. The values decreased smoothly from 23 erg/cm^2 for pure silver to 4.2 erg/cm^2 for 7.8 at.% tin. The results are compared with previous determinations in other silver-base alloys.

9503. **Low-frequency motions and barrier to rotation in phosphonium iodide,** J. J. Rush, *J. Chem. Phys.* **44,** No. 4, 1722-1723 (Feb. 15, 1966).

Key words: Barrier to rotation; electrostatic model; inelastic neutron scattering; phosphonium iodide (PH_4I).

The vibrational spectrum of PH_4I has been investigated by the energy-gain scattering of cold neutrons ($E_n \leq 5$ meV). Three distinct inelastic-scattering maxima are observed at energy gains corresponding to 110, 335, and 614 cm^{-1}. The 335 and 614 cm^{-1} peaks are attributed to the torsional oscillations of the PH_4^+ ion and the 110 cm^{-1} peak to the translational optic vibrations. The barrier to rotation for the torsional mode of 335 cm^{-1} was computed to be 7.1±0.5 kcal/mole based on the observed energy of the peak. This agrees well with the value of 7.5 kcal/mole derived from an electrostatic model.

9504. **Motions of water molecules in potassium ferrocyanide trihydrate, water, and ice: a neutron scattering study,** J. J. Rush, P. S. Leung, and T. I. Taylor, *J. Chem. Phys.* **45,** No. 4, 1312-1317 (Aug. 15, 1966).

Key words: Ferroelectrics; H_2O; ice; inelastic scattering; $K_4Fe(CN)_6 \cdot 3H_2O$; librations; low-frequency modes; neutron cross-sections; neutron spectra; phase transition.

The motions of H_2O molecules in ferroelectric potassium ferrocyanide trihydrate, water, and ice have been investigated by total cross section and differential inelastic scattering measurements with cold neutrons. The results show no significant change in the average rotational or translational freedom of the water molecules in KFCT at or near its ferroelectric transition. The inelastic neutron spectra for KFCT exhibit broad peaks at about 425 and 160 cm^{-1}, both above and below the transition, which are assigned primarily to the librational and optic translational modes of the H_2O molecules, respectively. Moreover, both the total cross section and inelastic scattering results indicate a greater freedom of motion of the H_2O molecules in the KFCT lattice than in either water or ice. In addition, a decrease in the total cross section of H_2O, and in its variation with neutron wavelength is observed at the water-ice transition, indicating a significant change in the frequency distribution. The neutron results are compared with the results of NMR and infrared measurements.

9505. **Neutron-scattering study of the motions of water molecules in hydrated salts of transition metals,** J. J. Rush, J. R. Ferraro, and A. Walker, *Inorg. Chem.* **6,** No. 2, 346-351 (Feb. 1967).

Key words: Cold neutrons; coordination; hydrated salts; hydrates; hydrogen-bonding; neutron scattering; vibration spectra; water librations.

The low-frequency motions of water molecules in a series of hydrated transition metal salts have been investigated by the energy-gain scattering of cold neutrons. The compounds studied include $CuSO_4 \cdot H_2O$, $CuSO_4 \cdot 5H_2O$, $Co(NO_3)_2 \cdot 2H_2O$, $Co(NO_3)_2 \cdot 6H_2O$, $Cu(NO_3)_2 \cdot 3H_2O$, and $UO_2(NO_3)_2 \cdot 6H_2O$. Broad bands observed in the spectra at neutron energy gains of 500-800 cm^{-1} are assigned to the wagging and rocking modes of the coordinated and hydrogen-bonded water molecules. Bands around 400-500 cm^{-1} are attributed both to M-OH_2 stretching modes and to the H_2O torsional vibrations around the bisectrix. Maxima are also observed at energy transfers below 300 cm^{-1}, which are tentatively assigned to hydrogen-bond stretching vibrations and possibly to H_2O-M-OH_2 deformation modes. Comparison of the various spectra appears to indicate that the average strength of binding of the water molecules does not change significantly in proceeding from the higher to the lower hydrates. The neutron results are compared in detail to previous infrared and structure results.

9506. **Vibration spectra of yttrium and uranium hydrides by the inelastic scattering of cold neutrons,** J. J. Rush, H. E. Flotow, D. W. Connor, and C. L. Thaper, *J. Chem. Phys.* **45,** No. 10, 3817-3825 (Nov. 15, 1966).

Key words: Cold neutrons; frequency; inelastic scattering; metal hydrides; neutron scattering; optical vibration; vibration spectrum.

The vibration spectra of the hydrides and deuterides of yttrium and uranium have been investigated by the energy-gain scattering of cold neutrons. The measured spectra are all split into two bands, one at higher energies, due to the optical hydrogen vibrations, and another at lower energies due to metal-atom vibrations. Values have been obtained for the peaks and widths of the single optical hydrogen bands in YH_2, YD_2, UH_3, and UD_3 by the calculation of approximate frequency distributions from the observed neutron time-of-flight spectra. The derived peak frequencies in cm^{-1} are: YH_2, 1025±60; YD_2, 725±40; UH_3, 970±60; UD_3, 710±40. The relative width at half-maximum for the hydrogen band in UH_3 is about double that for YH_2. The distribution of hydrogen vibrations in hexagonal YH_3 and YD_3 is considerably broader, and exhibits several maxima, due to hydrogens at different sites in the lattice. The hydrogen modes in all the compounds can be correlated reasonably well with the known crystal structures. The results are in satisfactory agreement with hydrogen frequencies calculated previously from heat-capacity data.

9507. **Unassigned.**

9508. **On the solution of the stefan problem for whisker growth,** J. A. Simmons, H. Oser, and S. R. Coriell, (Proc. Intern. Conf. Crystal Growth, Boston, Mass., June 20-24, 1966), *Crystal Growth, a Suppl. to J. Phys. Chem. Solids* **C8,** 255-264 (Pergamon Press Inc., New York, N.Y., 1967).

Key words: Curtis approximation; Dittmar-Neumann approximation; mean stay time; stefan problem; surface concentration; surface self-diffusion; whisker growth.

An integral equation which describes whisker length as a function of time is derived from the implicit exact solution of Simmons, Howard, and Parker using a conservation principle. A convergent iterative method is employed to obtain numerically the exact growth curves and concentration profiles. Utilizing a dimensionless formulation, growth curves are shown to comprise (except for a short transient period) a one-parameter family dependent only on a dimensionless evaporation parameter. The Dittmar-Neumann and Curtis approximations are compared with the exact solution and are found to deviate significantly in some parts of the growth range; however, in those parts of the growth range where physical limits on the surface concentration are satisfied, both approximations are in good agreement with the exact solution. Methods and limitations are discussed for calculating the coefficient of surface self-diffusion and mean stay time from whisker growth data.

9509. **Measurement of optical constants: optical constants of liquid mercury at 5461 Å,** L. E. Smith and R. R. Stromberg, *J. Opt. Soc. Am.* **56,** No. 11, 1539-1542 (Nov. 1966).

Key words: Complex refractive index; ellipsometry; mercury; optical constants; refractive index; surface films.

The optical constants of liquid mercury have been measured by ellipsometry at a wavelength of 5461 Å. Discrepancies among values from the literature are discussed and the magnitude of the important sources of error are evaluated. The effects on the measured index of several different types of surface films between the mercury and several contact media have been calculated and compared. Errors in alignment are shown to cause large changes in the measured refractive index as well as an apparent dependence upon the angle of incidence.

9510. **Relation between refractive index and density of glasses resulting from annealing compared with corresponding relation resulting from compression,** S. Spinner and R. M. Waxler, *Appl. Opt.* **5,** No. 12, 1887-1889 (Dec. 1966).

Key words: Annealing; density; glass; hydrostatic compression; polarizability; refractive index.

The change in refractive index and associated change in density of glasses on annealing has been determined by Tool, Tilton and Saunders. The corresponding changes for the same glasses, produced by hydrostatic compression, are presented here and compared with those of Tool, Tilton and Saunders. It is found that for a given increase in density on annealing the increase in index is greater than for the same measured increase in density on compression.

The results are interpreted in terms of equations developed by Lorentz-Lorenz, Pockels, and Mueller to show first, that in all cases, whether from annealing or compression, there is a decrease in polarizability on increase in density (these results are in agreement with those of previous investigators); and second, that the decrease in polarizability for a given increase in density is greater on compression than on annealing.

9511. **Elastic properties of NiTi as a function of temperature,** S. Spinner and A. G. Rozner, *J. Acoust. Soc. Am.* **40,** No. 5, 1009-1015 (Nov. 1966).

Key words: Annealed specimens; cold-worked specimens; elastic moduli; internal friction; nickel-titanium alloy; temperature dependence.

Young's modulus, shear modulus, and internal friction of the intermetallic compound NiTi have been measured as a function of temperature from about −180° to 600 °C, in the kilocycle-per-second range. Annealed and cold-worked specimens were used. All the specimens showed the same general pattern, with a minimum in elastic moduli occurring about 70°-140 °C, depending upon the particular specimen, and a maximum in internal friction occurring some 50 °C below the minimum in elastic modulus. Young's modulus was the same for all the specimens (694 kbar) within experimental error, but the shear modulus of the cold-worked specimens was more than 10% higher than that for the annealed specimens.

9512. **Interactions in aqueous nonelectrolyte solutions. I. Solute-solvent equilibria,** R. H. Stokes and R. A. Robinson, *J. Phys. Chem.* **70,** 2126-2131 (1966).

Key words: Hydration; mixed solutions; nonelectrolytes; solvation; sucrose solutions.

Solutes which interact with the solvent by a series of solvation equilibria to form species which mix according to the ideal solution law are considered. General expressions relating the solvent activity to the molality and the equilibrium constants are given. Sucrose solutions can be described with considerable accuracy by the assumption of a number of possible solvation sites equal to the number of oxygen atoms in the solute molecule, with a single equilibrium constant given the same value for each site.

Mixed solutions of several solutes conforming to this model are shown to obey very simple equations relating the molalities at isopiestic equilibrium between solutions of the separate and mixed solutes. A similar relation between the activity coefficients is given. Examples of systems which conform to these mixture relations are given, and it is suggested that cases of large departures from the relations may be taken as evidence of specific solute-solute interactions.

9513. **Thermal correction and crystal growth in horizontal boats, flow pattern, velocity measurement, and solute distribution,** H. P. Utech, W. S. Brower, and J. G. Early, (Proc. Intern. Conf. Crystal Growth, Boston, Mass., June 20-24, 1966), *Crystal Growth, a Suppl. to J. Phys. Chem. Solids* **B29,** 201-205 (Pergamon Press Inc., New York, N.Y., 1967).

Key words: Crystal growth; fused salts; magnetic fields; molten metals; solute distribution; thermal convection.

The characteristics of thermal convection in open horizontal boats containing molten metals or fused salts subject to a horizontal temperature gradient are shown in a motion picture. A technique for determining flow direction and mean flow velocity in systems whose convective flow is characterized by erratic temperature fluctuations (e.g. metals and salts) was developed and checked by comparing velocities measured by this technique with those observed directly in the molten salt.

The effectiveness of a magnetic field in suppressing convective flow is illustrated by comparing the distribution of solute in a specimen solidified unidirectionally in the presence of a field with the distribution in a sample grown normally, i.e. without any field.

9514. **Monte Carlo studies of lattice-model polymer chains. II. End-to-end length,** P. H. Verdier, *J. Chem. Phys.* **45,** No. 6, 2122-2128 (Sept. 15, 1966).

Key words: Distribution; end-to-end length; lattice model; Monte Carlo; polymer chain dynamics; relaxation; simulation.

The relaxation and the equilibrium behavior of lattice-model polymer chains are studied by simulation on a digital computer. Results are presented for the behavior of the square of end-to-end length l^2 for chains of 8, 16, 32, and 64 beads, with and without excluded volume restrictions. It is found that the relaxation of the lattice-model chains without excluded volume is remarkably similar to that of statistical-bead models. The introduction of excluded volume restrictions causes drastic qualitative changes in the relaxation behavior of the longer chains, and lengthens the time required for their relaxation by factors of up to 15. While the distribution in l^2 for the longer chains with excluded volume departs noticeably from Gaussian form at quite small and quite large values of l^2, it appears close to Gaussian in a range from one-third to three times the mean-square value of l^2.

9515. **Monte Carlo studies of lattice-model polymer chains. I. Correlation functions in the statistical-bead model,** P. H. Verdier, *J. Chem. Phys.* **45,** No. 6, 2118-2121 (Sept. 15, 1966).

Key words: Autocorrelation; correlation; end-to-end length; Fokker-Planck equation; polymer chain dynamics; radius of gyration; relaxation; statistical-bead model.

A method is presented for obtaining correlation functions in the free-draining statistical-bead model (Rouse model) of a polymer chain. Autocorrelation functions for the squares of end-to-end length and radius of gyration are given as functions of the number of statistical segments in the chain.

9516. **Unassigned.**

9517. **Nonstoichiometric A15-type phases in the systems Cr-Pt and Cr-Os,** R. M. Waterstrat and E. C. van Reuth, *Trans. Met. Soc. AIME* **236,** No. 8, 1232-1233 (Aug. 1966).

Key words: Alloy phases; atomic ordering; A15-type phases; chromium alloys; electron compounds; intermediate phases; nonstoichiometric phases; osmium alloys; platinum alloys; transition elements.

The composition ranges of stability for binary A15-type phases in the systems Cr-Pt and Cr-Os have been determined. These do not include the "ideal" A_3B stoichiometric composition at 1200 °C and 1400 °C respectively. X-ray diffraction studies reveal that long-range atomic ordering is incomplete in these phases with an unusually low degree of order occurring in the Cr-Os phase. Density measurements on the Cr-Os phase lead to the conclusion that there are insufficient vacant lattice sites in this phase to account for the apparent low degree of atomic ordering.

A composition shift is observed for the A15-type phases in the systems Cr-Pt, Cr-Ir, and Cr-Os which parallels a similar composition shift previously observed in binary sigma phases. This suggests that "electronic factors" may influence the stability of both the A15-type phases and the sigma phases.

9518. **Fermi controlled recombination as a junction design factor in GaAs laser diodes,** N. N. Winogradoff and H. K. Kessler, *Int. J. Electronics* **21,** No. 4, 329-335 (1966).

Key words: Compensated GaAs; epitaxial GaAs lasers; Fermi levels; radiative recombination.

Since our first observation of the enhancement of radiative recombination rates in GaAs p-n junctions produced by the incorporation of shallow donors in the p-type side of the junction, the effect has been found to be quite general and has also been observed in GaP. Although several models for the radiative process have been proposed they do not provide a satisfactory explanation of the role of compensation. A new model based on Shockley and Read's statistics of recombination through an impurity center is described. It provides agreement with the experimentally observed differences in the light output of diffused, graded, and narrow, abrupt p-n junctions with and without compensation in the p-type side, and with the difference in the time delay between the leading edge of the current pulse and the commencement of lasing in diffused and epitaxial GaAs lasers at room temperature.

9519. **Radiative recombination within a space-charge region in a semiconductor,** N. N. Winogradoff, *J. Appl. Phys.* **37,** No. 10, 3916-3917 (Sept. 1966).

Key words: Gallium arsenide; germanium; p-n junctions; radiative recombination; silicon; space charge regions.

Since light emission from forward biased junctions is usually due to radiative recombination through a recombination center, the minima in the light output observed when cathode rays or a narrow beam of light traversed a p-n junction can be explained in terms of the recombination statistics of the centers in the space charge region rather than in terms of the separation of the free carriers by the junction field as is commonly believed. Furthermore, it is shown that under certain conditions of excitation, the luminescence in the space charge region can be a maximum.

9520. **Specific heat of natural rubber and other elastomers above the glass transition temperature,** L. A. Wood and N. Bekkedahl, *J. Polymer Sci. Letters* **5,** 169-175 (1967).

Key words: Butadiene-acrylonitrile copolymer; butadiene-styrene copolymers; crystallization of rubber; elastomers; polybutadiene; polyethylene; polyisobutylene; rubber; specific heat.

A survey is given of literature values of the specific heat C_p as a function of temperature (above the glass transition temperature) for the elastomers, including natural rubber, polyisobutylene, polybutadiene, several butadiene-styrene copolymers, and a butadiene-acrylonitrile copolymer. The values of dC_p/dt (where t is the temperature) found for natural rubber were abnormally low in the range −68 to +2 °C and abnormally high in the range 17° to 47 °C. The most probable explanation is that crystallization of the unvulcanized rubber was predominating in the first range, and melting of these crystals was predominating in the second range.

9521. **Effect of sample thickness and operating voltage on the contrast of Kossel transmission photographs,** H. Yakowitz, *J. Appl. Phys.* **37,** No. 12, 4455-4458 (Nov. 1966).

Key words: Divergent x-ray beams; Kossel; Kossel sample preparation; photographic contrast; transmission of x rays; x-ray diffraction.

The photographic contrast of transmission Kossel patterns is examined in terms of the voltage and thickness variables since other parameters in the contrast equation generally cannot be controlled by the investigator; they are fixed functions of the material. It is shown that there is no single thickness yielding maximum contrast. However, manipulation of the contrast equation yields an approximation to the thickness and operating voltage relationship giving Kossel transmission photographs of nearly optimum contrast. Methods for calculating this relationship for any crystal-radiation combination are described. It is assumed throughout that the crystal is not completely free of imperfections; however, neither is the crystal assumed to be completely mosaic.

9522. **Ellipsometric errors due to multiple reflections in mica quarter-wave plates,** H. T. Yolken, R. M. Waxler, and J. Kruger, *J. Opt. Soc. Am.* **57,** No. 2, 283-284 (Feb. 1967).

Key words: Ellipsometer; multiple reflections; quarter-wave plate.

Experiments performed to determine the source of the large differences in polarizer readings between the ellipsometric zones found that the origin of these polarizer reading differences lay in multiple reflections occurring in the quarter-wave plate. Coating the quarter-wave plate with anti-reflective layers markedly reduced the zone differences.

9523. **Analysis and computer simulation of the production and distribution systems of a tufted carpet mill,** J. A. Yurow, *J. Ind. Eng.* **XVIII,** No. 1, 135-140 (Jan. 1967).

Key words: Industrial dynamics; simulation; tufted carpet mill.

The problem of simulating a multi-line tufted carpet mill by means of a continuous flow simulation language is translated into the problem of simulating a mill producing only four lines. Simulation of the planning and allocation of production time for each line under yarn availability constraints is studied in detail.

9524. **Simultaneous diffraction with the three-circle diffractometer,** M. Zocchi and A. Santoro, *Acta Cryst.* **22,** Pt. 3, 331-334 (Mar. 1967).

Key words: Diffraction; diffractometer; neutrons; simultaneous; three-circle; x ray.

The geometrical conditions of simultaneous diffraction with a three-circle diffractometer have been derived for all the crystal-systems and for any crystal orientation. It is shown that λ-independent simultaneous diffraction takes place among reciprocal lattice points located on the same vertical net, that multiplicity is generally odd, and that it obeys special conditions in all cases in the cubic system and, for particular orientations and classes of reflection, in the hexagonal and tetragonal systems. Finally, procedures are suggested for avoiding taking intensity measurements under conditions of simultaneous diffraction.

9525. **Spectral distribution of solar radiation at the earth's surface,** D. M. Gates, *Science* **151,** No. 3710, 523-529 (Feb. 1966).

Key words: Aerosol; air mass; ozone; solar radiation; spectral distribution; water vapor concentration; wavelength; wavenumber.

The spectral distribution of direct sunlight at the earth's surface at sea level is calculated as a function of the air mass and of aerosol, ozone, and water vapor concentration. A solar constant of 2.0 cal cm^{-2} min^{-1} is used for these calculations. The spectral distribution of sunlight is presented on a wavelength basis and also on a wavenumber basis. For sea level the spectral distributions of skylight and of global radiation incident on a horizontal surface are given. Finally, the variation with altitude of the spectral distribution of direct sunlight incident on a surface perpendicular to the sun's rays is presented.

9526. **Electrical feedthrough for pressures to 10 kbar,** P. L. M. Heydemann, *Rev. Sci. Instr. Laboratory Notes* **38,** No. 4, 558-559 (Apr. 1967).

Key words: Electrical connector; feedthrough; high pressure; resistance gage; ultrasonics.

For ultrasonic experiments at high pressure and for measurements with manganin resistance gages an electrical feedthrough was developed which is both easily fabricated and convenient to use. The electrical feedthrough (EFT) described here is designed for low current applications at frequencies ranging from d.c. to over 50 MHz. EFTs with one, two and four leads have been made. The insulation resistance between leads and between a lead and the shield is typically above 1000 MΩ. The EFT can therefore be used in connection with very sensitive bridge circuits. The EFT is made from parts that are easily available. It is readily attached to and removed from various kinds of high pressure equipment by means of a standard type fitting.

9527. **Relaxation of moments derived from a master equation,** K. E. Shuler and G. H. Weiss, *J. Chem. Phys.* **45,** No. 4, 1110-1112 (Aug. 15, 1966).

Key words: Exponential relaxation; master equation; moments; probability distributions; relaxation; transition probabilities.

Previous work on the relaxation of moments derived from a master equation [J. Math. Phys. **3,** 550 (1962)] has been extended to master equations for joint probability distributions and to nonlinear master equations involving product probability distributions. Necessary and sufficient conditions on the transition probabilities are given to obtain *closed* moment equations. The special case of simple, one-term, exponential relaxation of the moments is also discussed.

5. AVAILABILITY OF NBS PUBLICATIONS

5.1. PRICE LISTS

The following lists give the numbers and prices of all NBS publications issued from 1901 through December 31, 1967 which may be purchased from Federal Government sources. Order publications from the Superintendent of Documents, U.S. Government Printing Office or from the U.S. Department of Commerce Field Office nearest you. (See Purchase Procedures, page V).

When an item refers to "see —" the publication has been superseded by the one referenced and the price opposite the number is the sales price for the superseding publication. If "OP" is listed instead of a price, the superseding publication is *out of print*. (See Out-of-Print Material, page 110).

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54 see H3 & H4	OP
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131 see C385	OP
138 see C385	OP
139 see C390	OP
154 see H71	*
239 see C363	OP
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101 Vol. 1	1.00	182	.15	211 Vol. VI	.60
101 Vol. 2	1.00	183	.25	214	.35
103	1.00	184	.20	215	.25
120	.45	185	.40	216	.20
120A	1.00	186 see TN265	.50	217	.55
127	.60	187	.15	218	.30
129A	.50	188	.20	219	.45
		190	.40	220	.25
141	.25	191 (PB182538)	*	221	.20
145	.60	192	.25	222	.30
151	.20	193	1.00	223	.20
153	.30	194	.25	224	.20
154A (PB182435)	*	196	.20	225 (AD614056)	*

*Available only from the Clearinghouse; use "PB" or "AD" number when ordering.

TECHNICAL NOTES—continued

No.	Price	No.	Price	No.	Price
226	$0.40	282	$0.25	337	$0.45
227	.30	283	.35	339	.50
228	.20	284	.15	341	.25
229	1.25	285	.25	342	.40
230	.40	286	.25	343	.15
231	.25	287 (PB182436)	*	344	.20
232	.60	288	.30	345	.35
233	.20	289	.50	346	.25
234	.30	290	.25	347	.25
235	.25	291	.30	348	.40
236	.40	292	.50	349	.25
237	.15	294 (PB176289)	*	350	.25
240	.20	295	.25	351	.30
241	.25	296	.60	352	.25
243	.10	297	1.00	353	.10
244	.20	298	.40	354	.45
245	.35	299	.25	355	.20
246	.40	300	.50	356	.25
247	.40	301	.55	357	.30
248	.50	302	.60	358	.20
249	.40	303	.25	360	.50
252	.40	304 (AD615936)	*	362	.70
253	.10	305	.60	400	.55
255	.45	306	.75	401	.55
256	.25	307	.40	402	.50
258	.25	308	.50	403	.50
260	.50	309	.60	404	1.25
261	.25	310	.30	405	.60
262	1.00	311	.30	406	.70
		313	.45	409	.40
262-A	.50	314	.55	410	.25
263	.25	315	.25	411	.25
264	.50	316	.35	412	.15
265 see TN441	.55	318	.55	413	.30
266	.15	319	.55	414 (PB176109)	*
267	.45	321	.15	415	.50
269	.20	322	.20	416	.30
270-1 see TN270-3	1.25	323	.25	418	.15
270-2 see TN270-3	1.25	324	.30	420	.15
270-3	1.25	325	.30	421	.50
271	.60	326	.60	423	.50
272	.50	327	.20	425	.50
273	.50	328	.25	426	.40
274	.60	329	.35	427	.45
275	.50	330	.30	428	.55
276	1.00	331	.20	430	.20
277	.60	332	.60	431	.30
278	.30	333	.25	434	.20
279	.30	334 (PB173291)	*	435	.15
280	.25	335	.25	437	.25
281	$0.50	336	.30	438	.70

*Available only from the Clearinghouse; use "PB" or "AD" number when ordering.

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Vol.	Price	Vol.	Price
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71A (Jan.-Dec. 1967)	7.75	71C (Jan.-Dec. 1967)	4.25
69B (Jan.-Dec. 1965)	3.75		
70B (Jan.-Dec. 1966)	3.25		
71B (Jan.-Dec. 1967)	4.50		

5.2. SOURCES FOR REPRINTS OF NBS PAPERS IN PERIODICALS

		TYPE OF PAPER	
SOURCES	NBS Journal Research Papers[1] Prior July 1959	NBS Journal Research Papers July 1959 to Present	NBS-Authored Papers, non-NBS Media
Superintendent of Documents, GPO		See Footnote[3]	
Clearinghouse[2]	See Footnote[5]		
Author		X	X
Federal Depository Libraries[4]	X	X	
Library of Congress[6]	X	X	X
Original Media			X

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[1] RESEARCH PAPERS were reprints of individual articles that appeared in Volumes 1-62 of the monthly Journal of Research. These papers were published, numbered, and made available separately. In 1959 NBS began publishing the Journal of Research in separate sections, and RESEARCH PAPERS were discontinued.

[2] Address: Clearinghouse for Federal Scientific and Technical Information, National Bureau of Standards, U.S. Department of Commerce, Springfield, Virginia 22151.

[3] Bound volumes or (when available) the individual Journals may be purchased. See price list, page

[4] Primarily for reference; some libraries are equipped to reproduce copies for a fee. See Appendix A for list.

[5] Hard copy available at $3.00. Microfische copies also available at $.65. See Footnote (2) for address.

[6] Photoduplication Service, Library of Congress, Washington, D. C. 20540.

Those NBS publications not listed in the Price Lists, are out of print and are not available from the Superintendent of Documents. Many can be consulted at Libraries. Also, in many cases, photoduplicated copies can be purchased from the Library of Congress. For full information concerning this service, write to the Photoduplication Service, Library of Congress, Washington, D.C. 20540.

Certain NBS publications are out of print because they have been replaced, or partially replaced, by material issued by other organizations. In this connection, NBS is able to offer the following information:

Circular 410, National Standard Petroleum Oil Tables. Information in this Circular has been incorporated in the ASTM-IP Petroleum Measurement Tables issued by the American Society for Testing and Materials, 1916 Race Street, Philadelphia, Pa., 19103. Available at $8.75 ($6.50 to ASTM members). Tables 5 and 7 of the ASTM-IP Tables may also be purchased from the ASTM in separate reprint form at $1.50 a copy for the two tables.

Circular 438, Static Electricity. The National Fire Protection Association, 60 Batterymarch Street, Boston, Mass., 02110, has issued a publication by the same title, available from them as NFPA Publication 77M, at $1.00.

Circular 464, Gas Calorimeter Tables. The American Society for Testing and Materials, 1916 Race Street, Philadelphia, Pa., 19103, has issued a publication on this subject. Listed as ASTM D900-55, it can be ordered at 75 cents per copy.

Circular 499, Nuclear Data. The publication of nuclear data is being continued in a new journal entitled *Nuclear Data,* published by Academic Press, 111 Fifth Avenue, New York, N.Y., 10003.

Circular 564, Tables of Thermal Properties of Gases. A reprinted edition is available from Pergamon Press of London and New York, at $20.00. The chapter on Nitrogen by Woolley was reissued as NACA Technical Note 3271 (March 1956) and the chapter on Steam by Fano, Hubbell, and Beckett was reissued as NACA Technical Note 3273 (August 1956). Information on these two Technical Notes may be obtained from the Office of Technical Information, National Aeronautics and Space Agency, 1520 H Street, N.W., Washington, D.C., 20546.

Circular 576, Automotive Antifreezes. For information on this subject consult United States of America Standards Institute, 10 East 40th Street, New York, N. Y., 10016.

Circular 577 and Supplement, Energy Loss and Range of Electrons and Positrons. These have been superseded by NASA Special Publication 3012, available from the Clearinghouse for Federal Scientific and Technical Information, Springfield, Va., 22151, at $3.00 hardcopy and $.65 microfische Number N65-12506.

Circular 579, Underground Corrosion. Now available as PB168350 from the Clearinghouse for Federal Scientific and Technical Information, Springfield, Va., 22151, at $3.00 hard copy and $.65 microfische.

Miscellaneous Publication 179, American Standard Building Code Requirements for Minimum Design Loads in Buildings and Other Structures. United States of America Standards Institute, 10 East 40th Street, New York, N. Y., 10016, has issued a publication on this subject. Available from them as A58.1-1955, at $2.50.

Miscellaneous Publication 187, Directory of Commercial and College Laboratories. A new Directory of College and Commercial Testing Laboratories is published by the American Society for Testing and Materials, 1916 Race Street, Philadelphia, Pa. 19103, at $1.50.

Handbook 46, Code for Protection Against Lightning. A United States of America Standards Institute Code for Protection Against Lightning (NFPA No. 78-1963) is available from United States of America Standards Institute, 10 East 40th Street, New York, N. Y., 10016, at 75 cents.

Handbook 49, Recommendations for Waste Disposal of Phosphorus-32 and Iodine-131 for Medical Users. Reprints of this Handbook can be purchased at $.40 per copy from NCRP Publications, Post Office Box 4867, Washington, D.C. 20008.

Handbook 58, Radioactive Waste Disposal in the Ocean. Reprints of this Handbook can be purchased at $.45 per copy from NCRP Publications, Post Office Box 4867, Washington, D.C., 20008.

Handbook 71, Specifications for Dry Cells and Batteries. For more information on this Handbook, write to United States of America Standards Institute, 10 East 40th Street, New York, N. Y., 10016.

Handbook 76, Medical X-ray Protection Up to Three Million Volts. Reprints of this Handbook can be purchased at $.50 per copy from NCRP Publications, Post Office Box 4867, Washington, D.C. 20008.

Handbook 84, Radiation Quantities and Units, has been superseded by ICRU Report 11 and can be purchased at $1.00 per copy from ICRU Publications, Post Office Box 4869, Washington, D.C. 20008.

6. INDEXES

6.1. HOW TO USE THE INDEXES

In addition to the usual author index, a subject index is provided in the form of a permuted key-word index. In this type of index the key words in each publication or paper are arranged by shifting each group of key words along the horizontal printing line so that each key word in turn has an opportunity to appear alphabetically. The user is thus able to locate papers of interest to him through the subject-related words he finds in the key-word index.

The index symbols used in the author and key-word indexes are explained in the following three tables. These tables also give the pages on which the abstracts of the various publication series begin.

Table A. Symbols for the Nonperiodicals

Index Symbol	NBS Nonperiodical Series	Page Number
Mono.	Monographs	27
H	Handbooks	30
M	Miscellaneous Publications	31
AMS	Applied Mathematics Series	35
NSRDS	National Standard Reference Data Series	36
BSS	Building Science Series	38
CS	Commercial Standards	39
SPR	Simplified Practice Recommendations	40
PS	Product Standards	41
TN	Technical Notes	42

Table B. Symbols for the Periodicals

NBS Journal of Research	Index Symbol			Issue Date	Page Number
	Vol.	Sect.	No.		
Section A	J70	A	4	July-August 1966	1
	J70	A	5	September-October 1966	2
	J70	A	6	November-December 1966	2
	J71	A	1	January-February 1967	5
	J71	A	2	March-April 1967	6
	J71	A	3	May-June 1967	8
	J71	A	4	July-August 1967	9
	J71	A	5	September-October 1967	10
	J71	A	6	November-December 1967	11
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	J71	B	1	January-March 1967	15
	J71	B	2 & 3	April-September 1967	16
	J71	B	4	October-December 1967	17
Section C	J70	C	3	July-September 1966	20
	J70	C	4	October-December 1966	21
	J71	C	1	January-March 1967	22
	J71	C	2	April-June 1967	23
	J71	C	3	July-September 1967	24
	J71	C	4	October-December 1967	25

Table C. Symbols for the Papers Published By Others (1966-1967)

NBS Papers Published by Others (1966-1967)	Index Symbol	Page Number
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Calculation of kinetic parameters; Determination of activation energies; Preexponential factor; Stability of polymers; Thermogravimetric analysis; Variation of the activation energy; *9192*.

Calculations; Electronic states, energies of formation; Energies of motion; Interstitials; Point defects; Theory; Vacancies; Vibrational states; *M287*.

Calibration, high-frequency voltages; Measurement, microwave voltages; Voltage, high-frequency, calibration; Voltage measurements; Voltage Tee; *9266*.

Calibration, permanent magnet standards; Magnet standards; Permanent magnet standards; Reference magnets; *9245*.

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Calibration; Calibration designs; Combinatorial analysis; Difference sets; Incomplete block designs; Statistical experiment designs; Tournaments; Weighing designs; *J.* **71B** *4-237, 149-160 (1967)*.

Calibration; Commodity transfer; Cryogenic; Cryogenic processes; Density; Flowmeters; Mass flow; Mass flowmeters; Performance results; Propellant management; Substitute fluid; Volume flow; Accuracy; *9428*.

Calibration; Comparison; Effective aperture; Electromagnetic horns; Gain; Measurement; Microwave; Mismatch errors; Rayleigh distance; Standard gain horns; Antennas; *TN351*.

Calibration; Comparison calibration; Frequency range; Shaker; Vibration; Accelerometer; *9306*.

Calibration; Console; Electrical; Measurement; Ratio; Standards; Voltage; Volt box; *J.* **70C** *3-229, 173-185 (1966)*.

Calibration; Direct-current; High-voltage; Ratio; Safety; Standards enclosure; Transformer; Voltage-divider; Voltmeter; Alternating-current; *TN349*.

Calibration; Errors; Heating; Voltage divider; Volt-box; *9305*.

Calibration; Instrumentation; Interchangeability of parts; Mass production; Standardization; Testing; Basic and applied research; *9350*.

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Calibration of germanium resistors; Germanium resistors; Thermometry; *J.* **71C** *1-441, 29-41 (1967)*.

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Calorimetry; Complex ion; Enthalpy determination; KCl-CdCl$_2$ system; Molten salts; Calorimeter; *9485*.

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Carbon; Copper; Germanium; Ritz; Silicon; Spectrum; Standards; Ultraviolet; Vacuum; Wavelengths; *9338*.

Carbon; Fluorine; Heat of combustion; Polytetrafluoroethylene (Teflon); Refractory compounds; Aluminum borides; Boron; Boron carbide; *9270*.

Carbon atom production; Carbon atom reactions; Cyanogen azide; Force constants; Infrared spectrum; NCN free radical; Thermodynamic properties; Ultraviolet photolysis; *9369*.

Carbon atom reactions; Cyanogen azide; Force constants; Infrared spectrum; NCN free radical; Thermodynamic properties; Ultraviolet photolysis; Carbon atom production; *9369*.

Carbon dioxide; Carbon monoxide; Gas phase; Hydrogen atom; Hydroxyl-radical; Rate constant; Activation-energy; Atom-transfer reaction; *9328*.

Carbon II; Coulomb approximation; Electron density; Electron temperature; Equivalent electrons; Local thermal equilibrium; Oscillator strength (f-value); Optical depth; Oxygen II; Plasma; T-tube; *9388*.

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Carbon monoxide; Forbidden transition; High resolution; Spectrum; Vacuum ultraviolet; Absorption; *9330*.

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Carbon spectra; Electrodeless discharge; Germanium spectra; Nitrogen spectra; Silicon I; Silicon spectra; Vacuum ultraviolet standards; Atomic spectrum of silicon; *9337*.

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Carbonyl; Cobalt; Cobalt tetracarbonyl hydride; Hydride; Nuclear magnetic resonance; Proton; Bond length; Broad-line; *9449*.

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Cavitation nucleus; Cavitation threshold; Fission-induced cavitation; Neutron-induced cavitation; Radiation-induced cavitation; Threshold; Acoustic cavitation; Alpha-particle-induced cavitation; Cavitation; *J.* **71C** *4-261, 299-312 (1967)*.

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Cavity ionization chamber; Cobalt-60 gamma rays; Comparison; Graphite; $W \cdot \bar{s}_m$; Absorbed dose; Calorimeter; *J.* **71C** *1-440, 19-27 (1967)*.

Ceramic moving element; Electrodynamic shaker; Piezoelectric accelerometers; Reciprocity; Secondary standard; Vibration standard; Air bearing; *9297*.

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Chain folding; Crystal growth; Crystallization kinetics; Homogeneous nucleation; Interfacial energy; Nucleation; Polychlorotrifluoroethylene; Polyethylene; Polymers; Surface free energy; *9454*.

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Circular plates; Concentric loading; Design; Elasticity; Experiment; Maximum stresses; Symmetrical bending; Symmetrically distributed load; Theory; *J.* **71C** *1-438, 1-10 (1967)*.

Circular plates; Deflection; Elasticity; Experimental; Flexure; Point supports; Simplified approximate solutions; Thin plates; Bassali's theory; Concentric loading; *J.* **70C** *4-234, 227-244 (1966)*.

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Cleanability, porcelain enamel surfaces; Fluorescent soils; Porcelain enamel; Soil, residual; *9222.*

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Coaxial; Flow calorimeter; Radio frequency power; *J.* **71C** *2-250, 111-117 (1967).*

Coaxial choke; Mutual inductor; Stray magnetic field; Transformer; Auxiliary generator; Bridge; *J.* **70C** *4-233, 221-226 (1966).*

Coaxial techniques; Precision coaxial measurements; RF connector; *9381.*

Cobalt; Cobalt tetracarbonyl hydride; Hydride; Nuclear magnetic resonance; Proton; Bond length; Broad-line; Carbonyl; *9449.*

Cobalt; "releasing agents" in flame emission and atomic absorption; Magnesium; Ferrous SRMs; Stoichiometric mixtures uranium oxide; Isotope ratio determination; Spectrophotometric titration; Controlled potential coulometric; Molybdenum; *TN402.*

Cobalt tetracarbonyl hydride; Hydride; Nuclear magnetic resonance; Proton; Bond length; Broad-line; Carbonyl; Cobalt; *9449.*

Cobalt-60 gamma rays; Comparison; Graphite; $W\cdot\bar{s}_m$; Absorbed dose; Calorimeter; Cavity ionization chamber; *J.* **71C** *1-440, 19-27 (1967).*

CO by infrared absorbancy; Homogeneity; Certified value; Eighteen cooperating laboratories; Vacuum fusion; Inert gas fusion; Oxygen; Ferrous standard reference materials; *M260-14.*

Cockroft-Walton generator; Digital computers; Activation analysis; Standard reference materials; Photo-neutron reactions; Flux monitors; Cu, Se, Al, V in irons and steels; Homogeneity testing; Pneumatic rabbit sensor; Mossbauer spectroscopy; *TN404.*

Cockroft-Walton generator; Digital computers; Flux monitors; High precision 14 MeV neutron activation; Homogeneity testing; Instrumentation; NBS Linac; NBS reactor; Photoneutron reactions; Self absorption corrections; Standard reference materials; Vanadium in irons and steels; Activation analysis; Biological; Botanical samples; Carbon in sodium; *TN428.*

Coefficient of variation; Correlated estimators; Enthalpy adjustments; Heat of vaporization; High temperature chemistry; Overestimation of standard deviation; Second law heat; Slope estimators; Third law heat; Vapor pressure; *J.* **70A** *6-424, 533-539, (1966).*

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Cold neutrons; Coordination; Hydrated salts; Hydrates; Hydrogen-bonding; Neutron scattering; Vibration spectra; Water librations; *9505.*

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Color; Colorblindness; Colorimetry; Theories of color; Chromatic adaptation; *9162.*

Color; Contrast; Crispening; Opponent color theory; Surround color; Three components color theory; Chromatic induction; *9411.*

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Colorblindness; Colorimetry; Theories of color; Chromatic adaptation; Color; *9162.*

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Comparison; Effective aperture; Electromagnetic horns; Gain; Measurement; Microwave; Mismatch errors; Rayleigh distance; Standard gain horns; Antennas; Calibration; *TN351.*

Comparison; Graphite; $W\cdot\bar{s}_m$; Absorbed dose; Calorimeter; Cavity ionization chamber; Cobalt-60 gamma rays; *J.* **71C** *1-440, 19-27 (1967).*

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Field evaporation; Field ion microscopy; Hcp metals; Surface structure; *9484*.
Field gradient; Magnetic constants; Molecular electronic structure; Orbital energy; Polarizability; Quadrupole moment; Spectroscopic constants; *Ab initio* electronic calculation; Dipole moment; Dissociation energy; Electron affinity; Energy; *TN438*.
Field ion microscopy; Hcp metals; Surface structure; Field evaporation; *9484*.
Filling materials; Hardening; Shrinkage; Strain; Stress; Tensile; Adhesion; Bonding; Dental; *9433*.
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Fire; Flammability tests; Paints; Combustibility; Endurance; *9176*.
Fire endurance; Fire severity; Floor tests; Steel plate floors; Burnout tests; *BSS11*.
Fire load; Fire performance; Flame penetration; Potential heat; Structural load; Apartment dwelling; Burnout test; *BSS10*.
Fire performance; Flame penetration; Potential heat; Structural load; Apartment dwelling; Burnout test; Fire load; *BSS10*.
Fire severity; Floor tests; Steel plate floors; Burnout tests; Fire endurance; *BSS11*.
First spectrum; Multiplet table; Silicon; Spectrum, Si I; Wavelengths, Si I; Atomic energy levels; Atomic spectra Si I; *NSRDS-NBS3, Section 2*.
Fission-induced cavitation; Neutron-induced cavitation; Radiation-induced cavitation; Threshold; Acoustic cavitation; Alpha-particle-induced cavitation; Cavitation; Cavitation nucleus; Cavitation threshold; *J.* **71C** *4-261, 299-312 (1967)*.
Flame; Spectroscopy; Analytical emission; Atomic absorption; Electrical discharge; Bibliography; Indexed; *M281*.
Flame penetration; Potential heat; Structural load; Apartment dwelling; Burnout test; Fire load; Fire performance; *BSS10*.
Flame photometry; Spectroscopy; Atomic absorption spectrometry; Atomic emission spectrometry; Atomic fluorescence spectrometry; *9481*.
Flammability tests; Paints; Combustibility; Endurance; Fire; *9176*.
Flash photolysis; Gas phase; Hydrogen; Hydrogen deuteride; Insertion; Methane; Methyne; Rate; Vacuum ultraviolet; Acetylene; Combination; Ethane; Ethylene; *9286*.
Flash photolysis; Lifetime; Matrix isolation; Primary process; Decay; *9396*.
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Flexure; Point supports; Simplified approximate solutions; Thin plates; Bassali's theory; Concentric loading; Circular plates; Deflection; Elasticity; Experimental; *J.* **70C** *4-234, 227-244 (1966)*.
Flooring; Installation; Standards; Adhesive industrial; Characteristics; Conductive; *9177*.
Floor tests; Steel plate floors; Burnout tests; Fire endurance; Fire severity; *BSS11*.
Flow calorimeter; Radio frequency power; Coaxial; *J.* **71C** *2-250, 111-117 (1967)*.
Flow comparison; Fluid flow; Incompressible flow; Mass flow; Pressure drop; Compressible flow; *TN356*.
Flowmeter; Gas meter; Heat transfer; Laminar flow; Meter calibration; Compressible flow; *9390*.
Flowmeters; Mass flow; Mass flowmeters; Performance results; Propellant management; Substitute fluid; Volume flow; Accuracy; Calibration; Commodity transfer; Cryogenic; Cryogenic processes; Density; *9428*.
Flow properties; Kaolins; Surface area; Cation exchange capacity; Cone-plate viscometer; Crystallinity; *9491*.
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Fluid parahydrogen; Macroscopic polarizability; Dielectric polarizability; Dipole moment; *9248*.
Fluorescence; Hydrazoic acid; NH; Photolysis; Vacuum ultraviolet; *9417*.
Fluorescence; Hydrazoic acid; Nitrous oxide; Photolysis; Energy transfer; *9418*.
Fluorescence; Nitric oxide; Nitrogen dioxide; Nitrosyl chloride; Vacuum ultraviolet; *9416*.
Fluorescent soils; Porcelain enamel; Soil, residual; Cleanability, porcelain enamel surfaces; *9222*.
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Fluorine; Fluorine bomb calorimetry; Graphite; Heat of combustion; Heat of formation; Hydrogen fluoride aqueous; Teflon; Aluminum fluoride; Carbon tetrafluoride; *J.* **71A** *2-440, 105-118 (1967)*.
Fluorine; Heat of combustion; Heat of formation; Teflon; Aluminum diboride; α-aluminum dodecaboride; Aluminum fluoride; Bomb calorimeter; Boron trifluoride; *J.* **71A** *4-462, 307-315 (1967)*.
Fluorine; Heat of combustion; Polytetrafluoroethylene (Teflon); Refractory compounds; Aluminum borides; Boron; Boron carbide; Carbon; *9270*.
Fluorine; Heat of formation; Teflon; Bomb calorimeter; Boron; Boron trifluoride; *J.* **71A** *3-451, 195-202 (1967)*.
Fluorine; High temperature; Kinetics; Mass spectrometry; Nickel; Surface reaction; *9374*.
Fluorine; NMR; Polysilanes; Silicon; Sub-halides; Boron; *9229*.

Fluorine bomb calorimetry; Graphite; Heat of combustion; Heat of formation; Hydrogen fluoride aqueous; Teflon; Aluminum fluoride; Carbon tetrafluoride; Fluorine; *J.* **71A** *2-440, 105-118 (1967).*

Flush diaphragm; Pressure gage; Temperature; Temperature gradient; Transducers; *9258.*

Flux averaging devices; Infrared reflectance; Spectral reflectance; Spectral emittance; Specular reflectance; Averaging spheres; Diffuse reflectance; Emissivity; Emittance; *TN415.*

Flux monitors; Cu, Se, Al, V in irons and steels; Homogeneity testing; Pneumatic rabbit sensor; Mossbauer spectroscopy; Tin standard for chemical shift; PARLORS program for Mossbauer spectra; Mossbauer instrumentation; Mossbauer laboratories; *TN404.*

Flux monitors; High precision 14 MeV neutron activation; Homogeneity testing; Instrumentation; NBS Linac; NBS reactor; Photoneutron reactions; Self absorption corrections; Standard reference materials; Vanadium in irons and steels; Activation analysis; Biological; Botanical samples; Carbon in sodium; Cockroft-Walton generator; Digital computers; *TN428.*

Flux monitors; Mossbauer instrumentation; Mossbauer spectroscopy; NBS Linac; Nickel-61; PARLORS program for Mossbauer spectra; Photoneutron reaction; Solid state detectors; Standard reference materials; Tin standard for chemical shift; Computers; *TN421.*

Fokker-Planck equation; Polymer chain dynamics; Radius of gyration; Relaxation; Statistical-bead model; Autocorrelation; Correlation; End-to-end length; *9515.*

Folding; Gaussian; Square; Trapezoidal; Triangular; Dispersion; Distributions; *9398.*

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Force constants; HNF; HNF$_2$; Infrared spectrum; Matrix isolation; NF; NF$_2$; Thermodynamic properties; Visible-ultraviolet spectrum; F atom reactions; *9335.*

Force constants; Infrared spectra; Modes of vibration; Molecular vibrational frequencies; Molecular spectra; Raman spectra; Data; *NSRDS-NBS11.*

Force constants; Infrared spectrum; NCN free radical; Thermodynamic properties; Ultraviolet photolysis; Carbon atom production; Carbon atom reactions; Cyanogen azide; *9369.*

Force field; Infrared; Osmium tetraoxide; Vibration-rotation; Coriolis constant; *9349.*

Force fields; High resolution; Infrared; ν_3; Vibration-rotation; ζ_3; ζ_4; Band contours; BF$_3$; Coriolis force; *9268.*

Foreign standards laboratories; Laboratory management; Measurements and standards; Measurement system; National Conference of Standards Laboratories; Proceedings, 1966 Standards Laboratory Conference; Traceability; United States measurement system; *M291.*

Formula; Imprecision; Law of error; Products; Propagation of error; Random; Ratio; Systematic; Sum; Approximation; Error; *J.* **70C** *4-237, 263-273 (1966).*

Fortran program; Wigner coefficients; Quantum theory of angular momentum; 3j coefficient; 6j coefficient; 9j coefficient; Clebsch-Gordan coefficients; *TN409.*

Fourier expansion; *H*-groups; Automorphic forms; Discontinuous groups; *J.* **71B** *4-239, 167-169 (1967).*

Fourier series; Piecewise; Smoothing; Continuous function; *J.* **71C** *2-248, 93-100 (1967).*

Fourier-transform; Functional transforms; Generalized MacRobert's function; Hankel transform, *K*-transform; Laplace transform, MacRobert's function; *Y*-transform; *J.* **71B** *1-194, 23-37 (1967).*

Fourier transform; Function V(q); Harmonic oscillator; Matrix elements; *9420.*

Four-pi; Halpern; Neutron; Photoneutron; Response; Yields; Detector; Efficiency; *TN416.*

Four-terminal; Resistance decade; Transresistance; URS (universal ratio set); VERI (versatile ratio instrument); DRRS (direct reading ratio set); Junction; Precision measurements; Ratio; Resistor; *J.* **70C** *3-228, 169-172 (1966).*

Fracture mirror size; Modulus rupture; Thermally tempered glass; *9227.*

Fracture topography; Kinetics; Polymeric solids; Primary fracture front; Topography; Brittle polymers; *9487.*

Fragment ions; Ionization; Mass spectrometer; Molecule; NO$_2$; NO$_2^+$ N$_2$O$^+$; Photoionization; Threshold; Ultraviolet; Vacuum; Dissociation; *J.* **71A** *5-467, 371-378 (1967).*

Frame; Lineality space; Linear programming; Algorithm; Cone; Convex hull; Face; *J.* **71B** *1-189, 1-7 (1967).*

Frame embedding; Two-dimensional languages; Chinese characters; Grammar; Generative grammar; Component combination; Phrase structure grammar; Linguistics; *TN296.*

Free group; Handlebody; Homeomorphism; Simply connected; Topology; 3-manifold; 3-sphere; *J.* **71B** *2&3-197, 53-56 (1967).*

Free products; Groups; Representations; *9348.*

Free radical; Microwave spectrum; Structure; CF$_2$; Dipole moment; *9380.*

Free radicals; Ion-molecules reactions; Neopentane; Photolysis; Radiolysis; *9180.*

Free radicals; Polyvinyl alcohol; Polyethylene oxide; Tetrahydrofuran; Hydroxyl radicals; Electron spin resonance; *9175.*

Freezing liquid densities; Hydrogen; Melting-line liquid densities; Orthobaric densities; Parahydrogen; *J.* **70A** *6-425, 541-544 (1966).*

Freight operations; GPSS; Railroads; Scheduling; SIMSCRIPT; Simulation; Sorting; *9427.*

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Frequency; Fluorinated ethylene-propylene; Humidity; Polycarbonate; Polyethylene; Poly(1,4-cyclohexylenedimethylene terephthalate); Polystyrene; Poly(tetrafluoroethylene); Time; Reference specimens; Dielectric constant; *J.* **71C** *2-251, 119-125 (1967).*

Frequency; Inelastic scattering; Metal hydrides; Neutron scattering; Optical vibration; Vibration spectrum; Cold neutrons; *9506.*

Frequency; Superposition; Crystal; Structure; Patterson; Vector; Symmetry; Consistency; *J.* **70A** *4-407, 319-321 (1966).*

Frequency and time standards; Standards; Standard time scales; Atomic frequency standards; Atomic time; Cesium atomic beam; *9387.*

Frequency range; Magnetic core; Permeability techniques; *9196.*

Frequency range; Shaker; Vibration; Accelerometer; Calibration; Comparison calibration; *9306.*

Frequency shift; Radiation field; Resonance; Thallium; Atomic beam; *TN346.*

Frequency stability; Gage; High pressure; Self-excited pulse repetition; Temperature compensation; Ultrasonics; Velocity of sound; Delay line; *9331.*

Frequency standards; Gas cells; Performance (long term); Reliability; Rubidium; Stability; Aging; Calibration (USFS); *TN341.*

Frequency translator; Phase shifter; Universal time; *9152.*

Function; High pressure; *n*-hexane; Pressure; Three-terminal electrode set; Clausius-Mossotti; Density; Dielectric constant; Dilatometer; *J.* **71A** *4-460, 287-292 (1967).*

Functional analysis; Metric spaces; Topology; Contractions; *J.* **71B** *2&3-202, 73-76 (1967).*

Functional transforms; Generalized MacRobert's function; Hankel transform, *K*-transform; Laplace transform, MacRobert's function; *Y*-transform; Fourier-transform; *J.* **71B** *1-194, 23-37 (1967).*

Functions; Variables; Hermite-Fejer; Bernstein; Chebyshev; Approximations; Convergence; Multidimensional; Polynomials; *J.* **70B** *3-182, 211-218 (1966).*

Function V(q); Harmonic oscillator; Matrix elements; Fourier transform; *9420.*

Fungicide; Latex; Mercury; Paint; Analysis; Colorimetric; Dithizone; Paint film; *9431.*

Fused salts; Magnetic fields; Molten metals; Solute distribution; Thermal convection; Crystal growth; *9513.*

Fused silica; Infrared materials; Optical materials; Refractive index; Dispersion; *9190.*

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G*; Representation-mixing; Sum-rules; Vector current; Axial-vector current; Chiral; G_A; *9353.*

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GaAs lasers; Heat sink; Optical power; Aluminum-silicone compound; *9467.*

Gage; High pressure; Self-excited pulse repetition; Temperature compensation; Ultrasonics; Velocity of sound; Delay line; Frequency stability; *9331.*

Gain; Measurement; Microwave; Mismatch errors; Rayleigh distance; Standard gain horns; Antennas; Calibration; Comparison; Effective aperture; Electromagnetic horns; *TN351.*

Gain fluctuations; Imperfect multiplier; Noise comparison; Nonidentical amplifiers; Sine-wave comparison signal; Correlation radiometer; Differential time delay; *J.* **71C** *2-253, 153-170 (1967).*

Gallium arsenide; Germanium; P-n junctions; Radiative recombination; Silicon; Space charge regions; *9519.*

Gallium arsenide; Lasers; Light emission; Surface effects; Tunnel diodes; Degradation; *9468.*

Galvanic corrosion; Gypsum plaster; Aluminum conduit; Calcium chloride; Concrete; Corrosion in concrete; Corrosion in plaster; Dissimilar metals; *9497.*

Galvanic corrosion; Pitting; Pitting corrosion; Corrosion; Corrosion currents; Electroplating; *9490.*

Gamma irradiation; Polymer degradation; Postirradiative decay; Aqueous solution; Cross-linking; Dextran; Dextran triacetate; *J.* **71A** *1-433, 25-31 (1967).*

Gamma radiation; Polymerization; Pressure; Poly-5,5,5,4,4,3,3-heptafluoropentene-1; Poly-4,4,4,3,3,-pentafluorobutene-1; Poly-3,3,3-trifluoropropene; *9226.*

Gamma-ray penetration theory; Neutron penetration theory; Polynomial approximations; Biorthogonal functions; *J.* **71B** *4-244, 197-211 (1967).*

Gamma rays; Neutrons; Point source; Shielding; Single scatter; Air-scatter; Angular distribution; Energy spectrum; *9308.*

Garnet; Low magnetic field effects; Permeability; Spin waves; Tensor permeability; YIG; External tensor permeability; Ferrimagnetic resonance; Ferrites; *9395.*

Gas; Oxygen atom; Oxidation; Population distribution; Rotation; Acetylene; CH; Chemiluminescence; Cross section; Emission spectrum; Energy transfer; Experimental; *9288.*

Gas; Rate constants; Reactions; Tables; Activation energies; Arrhenius equation; Bimolecular; Chemical kinetics; Data; *NSRDS-NBS9.*

Gas analysis; Mass spectrometric gas analysis; Microchemical analysis; Polarographic analysis; Standard reference materials, analysis of; Stoichiometry; Atomic weights; Coulometric analysis; *TN403.*

Gas analysis; Mass spectrometric gas analysis; Microchemical analysis; Null-point potentiometry; Polarographic analysis; Standard reference materials, analysis; Coulometric analysis; *TN425.*

Gas bearings; Helium refrigeration; Performance; 9800 RPS; 200 Watts (30 °K); Design; Expansion turbine; *9151.*

Gas cells; Performance (long term); Reliability; Rubidium; Stability; Aging; Calibration (USFS); Frequency standards; *TN341.*

Gases; Liquids; Metals; Solids; Thermal conductivity; *NSRDS-NBS8.*

Gas meter; Heat transfer; Laminar flow; Meter calibration; Compressible flow; Flowmeter; *9390.*

Gas phase; Hydrogen; Hydrogen deuteride; Insertion; Methane; Methyne; Rate; Vacuum ultraviolet; Acetylene; Combination; Ethane; Ethylene; Flash photolysis; *9286.*

Gas phase; Hydrogen atom; Hydroxyl-radical; Rate constant; Activation-energy; Atom-transfer reaction; Carbon dioxide; Carbon monoxide; *9328.*

Gas phase; Microwave; Microwave absorption; Molecular beam; Permittivity; Refractive index; Spectroscopy; Dielectric constant; Electric dipole moments; *NSRDS-NBS10.*

Gas phase; Photolysis; Solid phase; Vacuum ultraviolet; Carbene; Ethylene; Ethylidene; *9415.*

Gaussian; Quadrature; Integration; *Mono. 98.*

Gaussian; Square; Trapezoidal; Triangular; Dispersion; Distributions; Folding; *9398.*

Gaussian quadrature; Integral equations; Numerical integration; Zeros of Legendre polynomials; *J.* **70B** *4-186, 249-256 (1966).*

Generalized inverse; Inequality; Matrix; *J.* **71B** *2&3-199, 61-64 (1967).*

Generalized inverse; Matrix; *EPr* matrices; *J.* **71B** *2&3-198, 57-60 (1967).*

Generalized inverse; Matrix; Partial isometry; *J.* **71B** *2&3-200, 65-67 (1967).*

Generalized inverse; Matrix; Partial; Isometry; *J.* **71B** *4-247, 225-228 (1967).*

Generalized inverse; Symmetrizable matrix; *J.* **71B** *4-248, 229-231 (1967).*

Generalized inversion curve; Joule-Thomson coefficient; Mixtures; Corresponding states; Cryogenic gases; *9456.*

Generalized MacRobert's function; Hankel transform, *K*-transform; Laplace transform, MacRobert's function; *Y*-transform; Fourier-transform; Functional transforms; *J.* **71B** *1-194, 23-37 (1967).*

Generating function; Lattice model; Partition function; Random walk; Adsorption; Chain polymer; Critical energy; *J.* **70B** *4-185, 237-247 (1966).*

Generative grammar; Component combination; Phrase structure grammar; Linguistics; Frame embedding; Two-dimensional languages; Chinese characters; Grammar; *TN296.*

Generator rank; Sylow subgroups; Bounds; Elementary abelian groups; *J.* **71B** *4-251, 247-248 (1967).*

Genus; Modular group; Congruence groups; *9164.*

Geomagnetic solar data; Solar data, geomagnetic; Data, geomagnetic and solar; *9181.*

Geomagnetism; Rotation of the earth; Westward drift; Core-mantle coupling; Decade fluctuations; Dynamo theory; Earth's core; *TN358.*

Geophysics; Gravity; Ionosphere; Seismology; *9274.*

Germanium; Kronig-Kramers dispersion relations; Optical properties; Sum rules; Characteristic electron energy loss; Far ultraviolet; *9345.*

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Germanium; Ritz; Silicon; Spectrum; Standards; Ultraviolet; Vacuum; Wavelengths; Carbon; Copper; *9338.*

Germanium resistor reproducibility; Low temperature thermometry; Reproducibility of germanium resistors; Thermal cycling at low temperature; Thermometry; Germanium resistors; *J.* **70C** *4-235, 245-254 (1966).*

Germanium resistors; Germanium resistor reproducibility; Low temperature thermometry; Reproducibility of germanium resistors; Thermal cycling at low temperature; Thermometry; *J.* **70C** *4-235, 245-254 (1966).*

Germanium resistors; Thermometry; Calibration of germanium resistors; *J.* **71C** *1-441, 29-41 (1967).*

Germanium spectra; Nitrogen spectra; Silicon I; Silicon spectra; Vacuum ultraviolet standards; Atomic spectrum of silicon; Carbon spectra; Electrodeless discharge; *9337.*

GeTe; Semiconductor; Superconducting energy gap; Tunnel junction; *9409.*

Geysering; Heat transfer to air condensing at 20 °K; Air collector; Air condensation; Air sampling; Air solidification at 20 °K; Cryodeposit; Cryodeposit surface temperature; Cryopumping; *9463.*

Giant quadrupole resonances; Photons; Absorption; Collective model; Cross section; Deformed nuclei; *9352.*

Giant resonance; Nuclear hydrodynamics; Octupole deformation; Photon absorption; Quadrupole resonance; Deformed nuclei; *9296.*

Gibbs energy; Heat capacity; Low temperature calorimetry; Thermodynamic properties; Beryllium 1:3-aluminate; Enthalpy; Entropy; *J.* **71A** *1-429, 3-8 (1967).*

Ginzburg Landau theory; Indium lead alloys; Superconductivity; *9240.*

Glass; Glass standard; Glass viscosity; Lead-silica glass; Restrained sphere; Rotating cylinders; Standard; Standard reference material; Viscosity; Viscosity standard; Beam bending; Fiber elongation; *M260-11.*

Glass; Hydrostatic compression; Polarizability; Refractive index; Annealing; Density; *9510.*

Glass; Index of refraction; Relaxation times; Two-relaxation time model; Volume relaxation; Annealing; Borosilicate crown glass; *J.* **71A** *3-456, 231-238 (1967).*

Glass; Molten salts; Conductance; Diffusion; Electrodes; Electrolysis; *9408.*

Glass electrodes; Medium effects; PH measurements; Acidity; Analysis; Conductance measurements; Electrochemical analysis; Electrochemistry of solutions; *TN423.*

Glassformers; Immiscibility; Liquid immiscibility; Modifiers, network; Oxide systems; Silicates; Borates; *9475.*

Glass research; Glass technology; Properties of glass; *9437.*

Glass standard; Glass viscosity; Lead-silica glass; Restrained sphere; Rotating cylinders; Standard; Standard reference material; Viscosity; Viscosity standard; Beam bending; Fiber elongation; Glass; *M260-11.*

Glass technology; Properties of glass; Glass research; *9437.*

Glass transformation; Heat capacity calorimetry; Molecular configurational state; Normal and supercooled liquid; Quenched glass; Residual (configurational) entropy; Thermodynamic properties; Annealed glass; Crystal; *J.* **71A** *4-461, 293-305 (1967).*

Glass viscosity; Lead-silica glass; Restrained sphere; Rotating cylinders; Standard; Standard reference material; Viscosity; Viscosity standard; Beam bending; Fiber elongation; Glass; Glass standard; *M260-11.*

Gloss; Light; Perception of color; Photometry; Physiological optics; Psychophysics; Scaling of color; Color; *9336.*

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Gomory algorithm; Integer programming; Linear inequalities; Maximization; *J.* **71B** *4-243, 187-195 (1967).*

Government; Operations research; Systems analysis; Conference proceedings; *M294.*

Government standardization, U. S.; Specifications; Standardization activities, U. S.; Standards; Test methods; Certification and labeling plans; *M288.*

GPSS; Railroads; Scheduling; SIMSCRIPT; Simulation; Sorting; Freight operations; *9427.*

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Grain, abrasive; Micron; Overgrade; Sedimentation; Sieve; Standard sieve; Abrasive grain; Accumulation curve; Coated abrasive products; *PS8-67.*

Grain boundaries; Impurities; Sapphire; Aluminium oxide; Dislocations; Electron microscopy; *9430.*

Grain-crack; Mullen test; Burst of leather; Extension; *9466.*

Grammar; Generative grammar; Component combination; Phrase structure grammar; Linguistics; Frame embedding; Two-dimensional languages; Chinese characters; *TN296.*

Graphic; Matroid; Binary; Bridge-separable; Even; *J.* **71B** *4-245, 213-214 (1967).*

Graphical solution; Hyperbolic character; Limiting values; Experimental; *TN435.*

Graphic arts; Photocomposition; Printing and publication; Automated type composition; Computerized typesetting; *Mono. 99.*

Graphite; Heat of combustion; Heat of formation; Hydrogen fluoride aqueous; Teflon; Aluminum fluoride; Carbon tetrafluoride; Fluorine; Fluorine bomb calorimetry; *J.* **71A** *2-440, 105-118 (1967).*

Graphite; Spectral radiance; Spectroradiometer; Temperature; Arc; Blackbody; *9326.*

Graphite; $W\cdot\bar{s}_m$; Absorbed dose; Calorimeter; Cavity ionization chamber; Cobalt-60 gamma rays; Comparison; *J.* **71C** *1-440, 19-27 (1967).*

Graphite arc; Pyrometry; Standard; Temperature; *9346.*

Graphs; Linear programming; Traveling salesman; Trees; Algorithms; Arborescences; Branchings; Combinatorics; *J.* **71B** *4-249, 233-240 (1967).*

Graph theory; Network flows; Mathematics; Segs; Basic cut-sets; Cut-sets; *J.* **71B** *4-242, 183-186 (1967).*

Gravity; Ionosphere; Seismology; Geophysics; *9274.*

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Gross heating value; Methane; Heating value; Heat of combustion; Reference material; *TN299.*

Group extension; Level; Modular group; Parabolic class number; Quotient surface; Split extension; Factor set; *9317.*

Group representations; Normal matrices; Schur's lemma; Simultaneous triangularization and diagonalization; Commuting matrices; *J.* **71B** *2&3-201, 69-71 (1967).*

Groups; Representations; Free products; *9348.*

Growth rate; Kinetics; Multicomponent; Steady-state; Composition; *9472.*

Gruneisen's constant; Interferometer; Rutile; Thermal expansion; Anisotropic crystal; *J.* **71A** *5-466, 363-369 (1967).*

G value; K-band spectrometer; $NiBr_2$; Single crystal; Antiferromagnetic; EPR; *9419.*

Gypsum plaster; Aluminum conduit; Calcium chloride; Concrete; Corrosion in concrete; Corrosion in plaster; Dissimilar metals; Galvanic corrosion; *9497.*

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Handbook; Human factors; Legibility; Psychology; Readability; Standards; Symbols; Type faces; Typography; Visibility; Alphanumeric characters; Displays; *M262-2*.

Handlebody; Homeomorphism; Simply connected; Topology; 3-manifold; 3-sphere; Free group; *J.* **71B** *2&3-197, 53-56 (1967)*.

Hankel transform, *K*-transform; Laplace transform, MacRobert's function; *Y*-transform; Fourier-transform; Functional transforms; Generalized MacRobert's function; *J.* **71B** *1-194, 23-37 (1967)*.

Hardboard; Ligno-cellulosic fibers; Lignin and hot pressed fibers; Fiber board; *CS251-63*.

Hardening; Heat treatment; Ni-maraging steels; Normalizing; Stainless steels; Structural steels; Surface hardening; Tempering; Tool steels; Annealing; Case hardening; Chemical composition; *Mono. 88*.

Hardening; Shrinkage; Strain; Stress; Tensile; Adhesion; Bonding; Dental; Filling materials; *9433*.

Hard spheres; Quantum statistics; Quantum virial coefficient; Second virial coefficient; *9282*.

Harmonic oscillator; Matrix elements; Fourier transform; Function V(q); *9420*.

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Hayward notation; Information retrieval; Linear notation; Structures; Substructure searches; Chemical; Computers; *9482*.

Hazards, electromagnetic radiation; Line, nonmetallic electrical transmission; Line, semiconducting plastic transmission; Meter, electric field-strength; Telemetry, novel form of; Device, electroexplosive ordnance; *J.* **71C** *1-443, 51-57 (1967)*.

Hazards, electromagnetic radiation; Line, non-metallic electrical transmission; Line, semi-conducting plastic transmission; Meter, electric field-strength; Telemetry, novel form of; Device, electro-explosive ordnance; Field, near-zone electromagnetic; *TN345*.

Hazards; Line; Meter; Telemetry; Device; Field; *9318*.

HCF_3 photolysis; Infrared spectrum; Matrix isolation technique; CF_2 reactions; CF_3 free radical; CF_3Br photolysis; F atom reactions; *9368*.

Hcp metals; Surface structure; Field evaporation; Field ion microscopy; *9484*.

He, He^-; Inelastic scattering; Resonances; Scattering; Angular difference; *9404*.

He; He_2; Metastable; Radiative; Spectra; Theory; Vacuum-ultraviolet; Atomic; Collisions; Continuous; Deexcitation; *9367*.

Heat capacity; Low temperature calorimetry; Thermodynamic properties; Beryllium 1:3-aluminate; Enthalpy; Entropy; Gibbs energy; *J.* **71A** *1-429, 3-8 (1967)*.

Heat capacity; Magnetization curves; Semiconducting $SrTiO_3$; Superconducting $SrTiO_3$; Critical fields; *9269*.

Heat capacity calorimetry; Molecular configurational state; Normal and supercooled liquid; Quenched glass; Residual (configurational) entropy; Thermodynamic properties; Annealed glass; Crystal; Diethyl phthalate; *J.* **71A** *4-461, 293-305 (1967)*.

Heat conduction; Heat generation; Heat transfer; Neutron absorption; Radioactive decay; Thermal conductivity; *J.* **71C** *4-260, 293-298 (1967)*.

Heat conductivity; Heat transfer; Iron; Lorenz function; Resistivity; Thermal conductivity; Armco iron; Conductivity; Electrical conductivity; Electrical resistivity; *J.* **71C** *4-259, 285-291 (1967)*.

Heat conductivity; Lorenz function; Platinum; Reference material; Resistivity; Standard; Thermal conductivity; Conductivity; Electrical conductivity; Electrical resistivity; *J.* **71C** *4-258, 255-284 (1967)*.

Heat flow; Interface; Kinetics; Morphology; Sphere; Stability; Crystal growth; Diffusion; *9439*.

Heat generation; Heat transfer; Neutron absorption; Radioactive decay; Thermal conductivity; Heat conduction; *J.* **71C** *4-260, 293-298 (1967)*.

Heating; Voltage divider; Volt-box; Calibration; Errors; *9305*.

Heating rate; Melting range; Melting temperature; Oriented; Partial melting; Recrystallization; Rubber; Slow melting; Stark rubber; Crystal size; Crystallized rubber; *J.* **71A** *3-455, 225-229 (1967)*.

Heating value; Heat of combustion; Reference material; Gross heating value; Methane; *TN299*.

Heat of combustion; Heat of formation; Teflon; Aluminum diboride; α-aluminum dodecaboride; Aluminum fluoride; Bomb calorimeter; Boron trifluoride; Fluorine; *J.* **71A** *4-462, 307-315 (1967)*.

Heat of combustion; Heat of formation; Hydrogen fluoride aqueous; Teflon; Aluminum fluoride; Carbon tetrafluoride; Fluorine; Fluorine bomb calorimetry; Graphite; *J.* **71A** *2-440, 105-118 (1967)*.

Heat of combustion; Polytetrafluoroethylene (Teflon); Refractory compounds; Aluminum borides; Boron; Boron carbide; Carbon; Fluorine; *9270*.

Heat of combustion; Reference material; Gross heating value; Methane; Heating value; *TN299*.

Heat of formation; Hydrogen fluoride aqueous; Teflon; Aluminum fluoride; Carbon tetrafluoride; Fluorine; Fluorine bomb calorimetry; Graphite; Heat of combustion; *J.* **71A** *2-440, 105-118 (1967)*.

Heat of formation; Teflon; Aluminum diboride; α-aluminum dodecaboride; Aluminum fluoride; Bomb calorimeter; Boron trifluoride; Fluorine; Heat of combustion; *J.* **71A** *4-462, 307-315 (1967)*.

Heat of formation; Teflon; Bomb calorimeter; Boron; Boron trifluoride; Fluorine; *J.* **71A** *3-451, 195-202 (1967)*.

Heat of reaction; Oxygen pressures; Silver oxide; Dissociation by heat; Entropy; Equilibrium; *9377*.

Heat of sublimation; Molecules; Potential functions; Empirical and semi-empirical; Transport properties; Virial coefficients; Atoms; Compressibility; *TN246*.

Heat of vaporization; High temperature chemistry; Overestimation of standard deviation; Second law heat; Slope estimators; Third law heat; Vapor pressure; Bias of least squares estimators; Coefficient of variation; *J.* **70A** *6-424, 533-539, (1966)*.

Heat of vaporization; Hydrogen; Parahydrogen; Specific heat; Thermodynamic function; Density; *9246*.

Heat sink; Optical power; Aluminum-silicone compound; GaAs lasers; *9467*.

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Heats of solution; Ion substitution; Lattice relaxation; Polarization energy; Shell calculations; Solid solutions; Alkali halides; *9300*.

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Heat transfer; Laminar flow; Meter calibration; Compressible flow; Flowmeter; Gas meter; *9390*.

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Heat transfer; Plane strain; Thermal stress; Yield stress; Elastic stress; *J.* **70B** *4-188, 265-272 (1966).*

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Heavier elements; Literature survey; Refractory compounds; Thermodynamic; Vaporization; Enthalpy; *9153.*

Heavy water; Ionization constant; Isotope effects; Deuterium oxide; *9440.*

Heavy water; PD scale; Acetic acid; Acidity in deuterium oxide; Deuterium oxide; Dissociation constant; *9170.*

Helium afterglow; Recombination coefficient; Brush-cathode plasma; Collisional-radiative recombination; *9371.*

Helium-methane; Low temperature; Phase-equilibrium; Solid-vapor; Experimental; *9230.*

Helium refrigeration; Performance; 9800 RPS; 200 Watts (30 °K); Design; Expansion turbine; Gas bearings; *9151.*

Helium-3; Helium-4; Liquid; Mixtures; Osmotic pressure; Quantum fluid; Specific heat; Thermodynamic properties; Cryogenics; Dilution refrigerator; Enthalpy; Entropy; Fermi-Dirac gas; *TN362.*

Helium-4; Liquid; Mixtures; Osmotic pressure; Quantum fluid; Specific heat; Thermodynamic properties; Cryogenics; Dilution refrigerator; Enthalpy; Entropy; Fermi-Dirac gas; Helium-3; *TN362.*

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Hexadecapole transitions; Phonon interactions; Saturation factor; 4-3m symmetry; Angular dependence; Hexadecapole; *9357.*

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HF; Noise; Satellite; Synchronization; Time and frequency dissemination; VHF; VLF; *TN357.*

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High precision 14 MeV neutron activation; Homogeneity testing; Instrumentation; NBS Linac; NBS reactor; Photoneutron reactions; Self absorption corrections; Standard reference materials; Vanadium in irons and steels; Activation analysis; Biological; Botanical samples; Carbon in sodium; Cockroft-Walton generator; Digital computers; Flux monitors; *TN428.*

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High pressure; *n*-hexane; Pressure; Three-terminal electrode set; Clausius-Mossotti; Density; Dielectric constant; Dilatometer; Function; *J.* **71A** *4-460, 287-292 (1967).*

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High pressure; Resistance gage; Ultrasonics; Electrical connector; Feedthrough; *9526.*

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High resolution; Spectrum; Vacuum ultraviolet; Absorption; Carbon monoxide; Forbidden transition; *9330.*

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High-temperature alloys; Nitrogen; Nitrogen and ambient air; Spark excitation; Alloys, high-temperature; Ambient air; Argon; Atmospheres of argon; *9235.*

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High-temperature calorimetry; Phase transition; Pretransition phenomena; Specific heat; Thermodynamic properties; Aluminum trifluoride; Drop calorimetry, enthalpy measurements; *J.* **71A** *3-450, 185-193 (1967).*

High temperature chemistry; Overestimation of standard deviation; Second law heat; Slope estimators; Third law heat; Vapor pressure; Bias of least squares estimators; Coefficient of variation; Correlated estimators; *J.* **70A** *6-424, 533-539, (1966).*

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High-voltage; Ratio; Safety; Standards enclosure; Transformer; Voltage-divider; Voltmeter; Alternating-current; Calibration; Direct-current; *TN349.*

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Homogeneity; Certified value; Eighteen cooperating laboratories; Vacuum fusion; Inert gas fusion; Oxygen; Ferrous standard reference materials; CO by infrared absorbancy; *M260-14.*

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Homogeneity testing; Instrumentation; NBS Linac; NBS reactor; Photoneutron reactions; Self absorption corrections; Standard reference materials; Vanadium in irons and steels; Activation analysis; Biological; Botanical samples; Carbon in sodium; Cockroft-Walton generator; Digital computers; Flux monitors; High precision 14 MeV neutron activation; *TN428.*

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Homogeneous nucleation; Interfacial energy; Nucleation; Polychlorotrifluoroethylene; Polyethylene; Polymers; Surface free energy: Chain folding; Crystal growth; Crystallization kinetics; *9454.*

Homogeneous precipitation; Aluminum; Beryllium: Thermoanalytical standards; Tricalcium silicate; Spectrophotometry; Antimony; High precision determination of nickel; Simultaneous determination copper; Cobalt; *TN402.*

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Humidity; Thin films; Vacuum; Adsorption; Barium fluoride; Electric hygrometer; *J.* **71C** *3-255, 199-207 (1967).*

Hydrated salts; Hydrates; Hydrogen-bonding; Neutron scattering; Vibration spectra; Water librations; Cold neutrons; Coordination: *9505.*

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Hydrogen; Melting-line liquid densities; Orthobaric densities; Parahydrogen; *J.* **70A** *6-425, 541-544 (1966).*

Hydrogen; Parahydrogen; *PVT*-relations; Thermodynamic properties; Equation of state; *J.* **71A** *3-452, 203-218 (1967).*

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Hydrogen chloride; Infrared; Rare gas matrix; Spectrum; Hydrogen bromide; *9359.*

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Linear algebra; Matroids; Systems of distinct representatives; Term rank; Algorithms; Combinatorics; Indeterminates; *J.* **71B** *4-250, 241-245 (1967).*

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Radiometric trace chromatography; Radioisotope dilution; Substoichiometry by controlled potential coulometry; Radiochemical separations; Theoretical detection limits for activation analysis; CLSQ program for multicomponent decay; Solid state detectors; *TN404*.

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Ratio; Safety; Standards enclosure; Transformer; Voltage-divider; Voltmeter; Alternating-current; Calibration; Direct-current; High-voltage; *TN349*.

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Recurrence methods; Special functions; Chebyshev series; Difference equations; Error analysis; Miller algorithm; *J.* **71B** *2&3-206, 111-129 (1967)*.

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Systematic; Sum; Approximation; Error; Formula; Imprecision; Law of error; Products; Propagation of error; Random; Ratio; *J.* **70C** *4-237, 263-273 (1966)*.

Systematic error; Sodium nitroprusside; Iron compounds; Optical Mossbauer spectrometer; Tandem Mossbauer spectrometer; Velocity calibration; Mossbauer; Spectroscopy; Standard; Differential chemical shift; Quadrupole splitting; Random error; *M260-13*.

Systems analysis; Alphanumeric compression; Information handling; High-speed information transmission; Information storage and retrieval; Numeric compression; *TN413*.

Systems analysis; Conference proceedings; Government; Operations research; *M294*.

Systems analysis; State of the art; Benefit-cost analysis; Transportation economics; Transport systems; *TN294*.

Systems analysis; Transportation planning; Urban transportation; Data processing; *9474*.

Systems of differential equations; Numerical integration; Propagation of error; Stability; *J.* **71B** *2&3-204, 91-103 (1967)*.

Systems of distinct representatives; Term rank; Algorithms; Combinatorics; Interdeterminates; Linear algebra; Matroids; *J.* **71B** *4-250, 241-245 (1967)*.

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Tables; Activation energies; Arrhenius equation; Bimolecular; Chemical kinetics; Data; Gas; Rate constants; Reactions; *NSRDS-NBS9*.

Tables; Force; Constants; Spectral; Molecular; Vibrational; Frequencies; Data; *NSRDS-NBS6*.

Tabulation; Basing connections; Characteristics; Electron tubes; Similar types; *H103*.

Tabulation; Characteristics tabulation; Electron tubes; Microwave electron tubes; *H104*.

Tan δ; Torsion pendulum; Varying crystallinities; Apparatus; Isothermally crystallized sample; Loss compliance; Loss modulus; Mechanical relaxation; Polychlorotrifluoroethylene; Quenched sample; Storage modulus; *9441*.

Tandem Mossbauer spectrometer; Velocity calibration; Mossbauer; Spectroscopy; Standard; Differential chemical shift; Quadrupole splitting; Random error; Systematic error; Sodium nitroprusside; Iron compounds; Optical Mossbauer spectrometer; *M260-13*.

Tanks; Valves; Bowls; Brass; Dimensions; Nuts; Plastic; Plimbing equipment; *PS6-66*.

Technetium, spectra of; Wavelengths of technetium; Spectra of technetium; *J.* **71A** *6-471, 547-565 (1967)*.

Technical highlights; Annual report; *M283*.

Technical highlights; Annual report; *M293*.

Technical personnel; Environment; Personnel; Professional environment; Professional personnel; Scientists and engineers; Standing committee; *9271*.

Techniques of vacuum measurement; Vacuum index; Vacuum measurement; Bibliography; Low pressure measurement; *Mono. 35, Supplement 1*.

Technology; World trade; Developing countries; International standards; Role of government; Role of private enterprise; *M284*.

Teeth; Bonding; Coupling agent; Denture; Plastic; Porcelain adhesion; Resin; Silane; *9494*.

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Teflon; Aluminum fluoride; Carbon tetrafluoride; Fluorine; Fluorine bomb calorimetry; Graphite; Heat of combustion; Heat of formation; Hydrogen fluoride aqueous; *J.* **71A** *2-440, 105-118 (1967)*.

Teflon; Bomb calorimeter; Boron; Boron trifluoride; Fluorine; Heat of formation; *J.* **71A** *3-451, 195-202 (1967)*.

Telecommunication; United States; Atmospheric research; Electromagnetic; *9158*.

Telemetry, novel form of; Device, electroexplosive ordnance; Field, near-zone electromagnetic; Hazards, electromagnetic radiation; Line, nonmetallic electrical transmission; Line, semiconducting plastic transmission; *J.* **71C** *1-443, 51-57 (1967)*.

Telemetry, novel form of; Device, electro-explosive ordnance; Field, near-zone electromagnetic; Hazards, electromagnetic radiation; Line, non-metallic electrical transmission; Line, semi-conducting plastic transmission; Meter, electric field-strength; *TN345*.

Telemetry; Device; Field; Hazards; Line; Meter; *9318*.

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Tellurium; Ultrasonics; Compressibility; Cylinder distortion; High pressure; Nickel; *J.* **71C** *1-439, 11-17 (1967)*.

Temperature; Arc; Blackbody; Graphite; Spectral radiance; Spectroradiometer; *9326*.

Temperature; Blackbody; International Practical Temperature Scale; Optical; Photoelectric pyrometer; Radiance sources; Standards; *9347*.

Temperature; Graphite arc; Pyrometry; Standard; *9346*.

Temperature; Infrared pyrometer; International Practical Temperature Scale; Optical pyrometer; Radiation thermometry; Standards; *9343*.

Temperature; Temperature gradient; Transducers; Flush diaphragm; Pressure gage; *9258*.

Temperature; Thermometry; Thermocouples; Thermistors; Resistance thermometer; Radiation pyrometry; *Mono. 27, Supplement 2*.

Temperature; Total energy; Bulk viscosity; Macroscopic equations of motion; Macroscopic variable; Non-equilibrium kinetic energy; *9313*.

Temperature coefficient; Collagen; End-to-end bonding; Hydrophobic bonding; Lateral aggregation; Native aggregation; *9436*.

Temperature compensation; Ultrasonics; Velocity of sound; Delay line; Frequency stability; Gage; High pressure; Self-excited pulse repetition; *9331*.

Temperature dependence; Annealed specimens; Cold-worked specimens; Elastic moduli; Internal friction; Nickel-titanium alloy; *9511*.

Temperature dependence; Viscosity of parahydrogen; Liquid normal hydrogen; Parahydrogen; Shear viscosity; *9201*.

Temperature gradient; Transducers; Flush diaphragm; Pressure gage; Temperature; *9258*.

Temperature gradient zone melting; Traveling solvent; Calcium molybdate; Crystal growth; Lithium sulfate; Single crystals; *9496*.

Temperature measurement; Temperature pattern; Diameter ratio; Mixing effectiveness; Square-edged orifice; *BSS12*.

Temperature pattern; Diameter ratio; Mixing effectiveness; Square-edged orifice; Temperature measurement; *BSS12*.

Temperatures; Triple-point region; T-S diagram; Enthalpy; Entropy; Parahydrogen; Pressure-volume; Properties; *TN343*.

Tempering; Tool steels; Annealing; Case hardening; Chemical composition; Hardening; Heat treatment; Ni-maraging steels; Normalizing; Stainless steels; Structural steels; Surface hardening; *Mono. 88*.

Tendon; Bone; Collagen; Hydroxyapatite; Piezoelectricity; Pyroelectricity; *9470*.

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Tensor permeability; Degenerate mode cavity; L-band cavity; Polycrystalline garnets; *J.* **71C** *1-445, 69-75 (1967)*.

Tensor permeability; YIG; External tensor permeability; Ferrimagnetic resonance; Ferrites; Garnet; Low magnetic field effects; Permeability; Spin waves; *9395*.

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Term rank; Algorithms; Combinatorics; Indeterminates; Linear algebra; Matroids; Systems of distinct representatives; *J.* **71B** *4-250, 241-245 (1967)*.

Term values; Wavefunctions; Multiplet strength; Self-consistent field; *J.* **71A** *2-447, 157-162 (1967)*.

Testing; Basic and applied research; Calibration; Instrumentation; Interchangeability of parts; Mass production; Standardization; *9350*.

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Testing of lenses; Interferometer; Lens aberrations; Prism interferometer; *9231*.

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Test methods; Certification and labeling plans; Government standardization, U. S.; Specifications; Standardization activities, U. S.; Standards; *M288*.

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Tetrahedral; Crystal structure; Dichloro(1,10-phenanthroline)-zinc; Molecular structure; *9499*.

Tetrahydrofuran; Hydroxyl radicals; Electron spin resonance; Free radicals; Polyvinyl alcohol; Polyethylene oxide; *9175*.

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Textiles; Fading standardization; Light-sensitive paper; Booklets of faded strips; Fading characteristics; *M260-15*.

TFE-fluorocarbon; Coatings, dry film; Dry film lubrication; Polytetrafluoroethylene; Resin sintered coatings; *CS274-66*.

TFE-fluorocarbon; Electrical tape, plastic; Plastic tape; Polytetrafluoroethylene; Resin skived tape; Skived tape; *PS3-66*.

Thallium; Atomic beam; Frequency shift; Radiation field; Resonance; *TN346*.

Theoretical; Third spectra; Configurations $4d^n+4d^{n-1}5s$, energy levels; Interaction parameters; Palladium group; *J.* **70A** *5-415, 435-445 (1966)*.

Theoretical; Unimolecular dissociation; Activated complex; Activated molecules; Activated state; Decay; Dissociation; High pressure rate constant; Kinetics; Lifetime; Mass spectra; Metastable molecules; Predissociation; Quantum mechanics; *9366*.

Theoretical detection limits for activation analysis; CLSQ program for multicomponent decay; Solid state detectors; Electronic data handling; NBS reactor; NBS Linac; Cockroft-Walton generator; Digital computers; Activation analysis; *TN404*.

Theoretical physics; Nuclear physics; Photonuclear absorption cross sections; Spherical nuclei; *9214*.

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Theory; Circular plates; Concentric loading; Design; Elasticity; Experiment; Maximum stresses; Symmetrical bending; Symmetrically distributed load; *J.* **71C** *1-438, 1-10 (1967)*.

Theory; Diffusion coefficient; Polymer; Solution; *9425*.

Theory; Transport properties; Correlation; Equilibrium properties; Experimental data; Intermolecular potential function; *TN360*.

Theory; Vacancies; Vibrational states; Calculations; Electronic states, energies of formation; Energies of motion; Interstitials; Point defects; *M287*.

Theory; Vacuum-ultraviolet; Atomic; Collisions; Continuous; Deexcitation; He; He_2; Metastable; Radiative; Spectra; *9367*.

Thermal breakdown; Transistors; Bibliography; Device reliability; Diodes; Failure mechanisms; Failure modes; Second breakdown; Semiconductor devices; *TN431*.

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Thermal conductivity; Armco iron; Conductivity; Electrical conductivity; Electrical resistivity; Heat conductivity; Heat transfer; Iron; Lorenz function; Resistivity; *J.* **71C** *4-259, 285-291 (1967)*.

Thermal conductivity; Conductivity; Electrical conductivity; Electrical resistivity; Heat conductivity; Lorenz function; Platinum; Reference material; Resistivity; Standard; *J* **71C** *4-258, 255-284 (1967)*.

Thermal conductivity; Gases; Liquids; Metals; Solids; *NSRDS-NBS8*.

Thermal conductivity; Heat conduction; Heat generation; Heat transfer; Neutron absorption; Radioactive decay; *J.* **71C** *4-260, 293-298 (1967)*.

Thermal conductivity; Transport coefficients; Triple collisions; Viscosity; Dense gases; Rigid disks; Rigid spheres; *9399*.

Thermal conductivity; Transport properties; Triple collisions; Viscosity; Dense gases; Rigid spheres; *9400*.

Thermal convection; Crystal growth; Fused salts; Magnetic fields; Molten metals; Solute distribution; *9513*.

Thermal cycling at low temperature; Thermometry; Germanium resistors; Germanium resistor reproducibility; Low temperature thermometry; Reproducibility of germanium resistors; *J.* **70C** *4-235, 245-254 (1966)*.

Thermal decomposition; Thermogravimetry; Thermolysis; Stability of polymers; Degradation; Nonisothermal kinetics; Polymers; Pyrolysis; *J.* **70A** *6-422, 487-523 (1966)*.

Thermal decomposition; Thermal volatilization; 1,2-dihydronaphthalene; Degradation; Polymerization; Pyrolysis; *9218*.

Thermal diffusivity of earth; Earth temperature; Least squares technique; *J.* **71C** *1-442, 43-50 (1967)*.

Thermal expansion; Anisotropic crystal; Gruneisen's constant; Interferometer; Rutile; *J.* **71A** *5-466, 363-369 (1967)*.

Thermal expansion; Controlled-gradient vacuum furnace; Elevated temperatures; Optical comparator; *J.* **71C** *2-247, 85-91 (1967)*.

Thermal expansion; Ferromagnetism; Hyperfine field; NMR; Nuclear interaction; Nuclear quadrupole resonance; *9219*.

Thermal insulation; Thermal performance standards; Indoor thermal environment; Insulated construction; Insulation research; Thermal building design; *9498*.

Thermally tempered glass; Fracture mirror size; Modulus rupture; *9227*.

Thermal neutron flux; Absolute gamma ray source strength; Black glass beads; *9435*.

Thermal performance standards; Indoor thermal environment; Insulated construction; Insulation research; Thermal building design; Thermal insulation; *9498*.

Thermal radiation; Computational methods; Emissivity; Emittance measurements; Radiant heat transfer; Reflectance measurements; *9303*.

Thermal radiation; Thoria; Zirconia; Alumina; Ceramic oxides; Emittance; Error sources; Magnesia; Measurement uncertainties; Spectral emittance; *J.* **70A** *5-412, 393-415 (1966)*.

Thermal radiation; Total emittance; Emissivity; Emittance; High temperature reflectance; Infrared reflectance; Radiation properties; Reflectance; Spectral emittance; Spectral reflectance; *TN292*.

Thermal radiation; V-grooves; Reflectance; Specular walls; *J.* **70C** *4-238, 275-280 (1966)*.

Thermal shock; Built-up roof membrane; Innovation; Preventive measures; Splitting failures; *9207*.

Thermal-shock resistance factor; Development; Roofing membrane; Strength properties; Thermally-induced forces; *BSS9*.

Thermal stress; Yield stress; Elastic stress; Heat transfer; Plane strain; *J.* **70B** *4-188, 265-272 (1966)*.

Thermal structure; Atmospheric resonances; Auroral infrasound; Infrasonic waves; *9186*.

Thermal volatilization; 1,2-dihydronaphthalene; Degradation; Polymerization; Pyrolysis; Thermal decomposition; *9218*.

Thermal voltage converter; Inductive voltage divider; Measurement; Phase-angle; Standard; Audio frequency; *TN347*.

Thermally-induced forces; Thermal-shock resistance factor; Development; Roofing membrane; Strength properties; *BSS9*.

Thermistors; Resistance thermometer; Radiation pyrometry; Temperature; Thermometry; Thermocouples; *Mono. 27, Supplement 2*.

Thermoanalytical standards; Tricalcium silicate; Spectrophotometry; Antimony; High precision determination of nickel; Simultaneous determination copper; Cobalt; "releasing agents" in flame emission and atomic absorption; Magnesium; Ferrous SRMs; *TN402*.

Thermistors; Resistance thermometer; Radiation pyrometry; Temperature; Thermometry; Thermocouples; *Mono. 27, Supplement 2*.

Thermodynamic; Vaporization; Enthalpy; Heavier elements; Literature survey; Refractory compounds; *9153*.

Thermodynamic and transport properties; Cryogenic data center; Cryogenic fluids; Low temperature properties of materials; NBS cryogenic data center; *9255*.

Thermodynamic function; Density; Heat of vaporization; Hydrogen; Parahydrogen; Specific heat; *9246*.

Thermodynamic functions; Decomposition pressures; Sulfates; *NSRDS-NBS7*.

Thermodynamic properties; Cryogenics; Dilution refrigerator; Enthalpy; Entropy; Fermi-Dirac gas; Helium-3; Helium-4; Liquid; Mixtures; Osmotic pressure; Quantum fluid; Specific heat; *TN362*.

Thermodynamic properties; Annealed glass; Crystal; Diethyl phthalate; Glass transformation; Heat capacity calorimetry; Molecular configurational state; Normal and supercooled liquid; Quenched glass; *J.* **71A** *4-461, 293-305 (1967)*.

Thermodynamic properties; Convergence temperature; Melting temperatures; Methyl surfaces; *n*-paraffins; Polyethylene; *J.* **70A** *6-421, 481-486 (1966)*.

Thermodynamic properties; Beryllium 1:3-aluminate; Enthalpy; Entropy; Gibbs energy; Heat capacity; Low temperature calorimetry; *J.* **71A** *1-429, 3-8 (1967)*.

Thermodynamic properties; Beryllium aluminate; Chrysoberyl, drop calorimetry; Enthalpy measurements; High-temperature calorimetry; Mixed oxides; Specific heat; *J.* **71A** *2-438, 89-95 (1967)*.

Thermodynamic properties; Beryllium aluminate (1:3); Drop calorimetry; Enthalpy measurements; High-temperature calorimetry; Mixed oxides; Specific heat; *J.* **71A** *2-439, 97-103 (1967)*.

Thermodynamic properties; Aluminum trifluoride; Drop calorimetry, enthalpy measurements; High-temperature calorimetry; Phase transition; Pretransition phenomena; Specific heat; *J.* **71A** *3-450, 185-193 (1967)*.

Thermodynamic properties; Equation of state; Hydrogen; Parahydrogen; *PVT*-relations; *J.* **71A** *3-452, 203-218 (1967)*.

Thermodynamic properties; Thermodynamics, rigid-rotor; Rigid-rotor, high temperatures; *9263*.

Thermodynamic properties; Visible-ultraviolet spectrum; F atom reactions; Force constants; HNF; HNF_2; Infrared spectrum; Matrix isolation; NF; NF_2; *9335*.

Thermodynamic properties; Ultraviolet photolysis; Carbon atom production; Carbon atom reactions; Cyanogen azide; Force constants; Infrared spectrum; NCN free radical; *9369*.

Thermodynamic properties; Elastic constants; Lattice dynamics; Lattice parameter changes; Single crystal ice; Speed of sound; *9383*.

Thermodynamic properties; Three-parameter theorem; Argon; Molecular complexity; Molecular thermodynamics; Prigogine's cell theory; *9386*.

Thermodynamic quantities; Bases; Dissociation constant; Emf measurements; Morpholine; Morpholinium ion; *9460*.

Thermodynamics, rigid-rotor; Rigid-rotor, high temperatures; Thermodynamic properties; *9263*.

Thermodynamics; Acid-base equilibria; Aminopyridine; Dissociation constant; Electrolytic dissociation; Methanol-water solvents; *9493*.

Thermodynamics; Acidity; Analytical chemistry; Conductance; Deuterium oxide; Dissociation processes; Electrochemistry; Electrolytes; Emf; Indicators; Isopiestic; Vapor pressure; Methanol-water solvents; *TN400*.

Thermodynamics; Beryllium oxide; Calorimetry; Chemical propulsion; Equilibrium; Estimates; *9301*.

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Thermodynamics; Weak electrolytes; Acetic acid-d_4; Acid-base; Deuterium oxide; Dissociation constants; Emf; Ionization; Isotope effects; *9492*.

Thermoelectric; Connector; Electromotive force; Oil baths; Standard cells; *TN353*.

Thermogravimetric analysis; Variation of the activation energy; Calculation of kinetic parameters; Determination of activation energies; Preexponential factor; Stability of polymers; *9192*.

Thermogravimetry; Energy of activation; Initial kinetic parameters; Non-isothermal kinetics; Polyethylene; Polymer degradation; Stability of polymers; *9451*.

Thermogravimetry; Thermolysis; Stability of polymers; Degradation; Nonisothermal kinetics; Polymers; Pyrolysis; Thermal decomposition; *J.* **70A** *6-422, 487-523 (1966)*.

Thermolysis; Stability of polymers; Degradation; Nonisothermal kinetics; Polymers; Pyrolysis; Thermal decomposition; Thermogravimetry; *J.* **70A** *6-422, 487-523 (1966)*.

Thermolytic chain scission; Copolymer; Ethylene-propylene; Linear polyethylene; Stress relaxation; *9264*.

Thermometry; Calibration of germanium resistors; Germanium resistors; *J.* **71C** *1-441, 29-41 (1967)*.

Thermometry; Germanium resistors; Germanium resistor reproducibility; Low temperature thermometry; Reproducibility of germanium resistors; Thermal cycling at low temperature; *J.* **70C** *4-235, 245-254 (1966)*.

Thermometry; Thermocouples; Thermistors; Resistance thermometer; Radiation pyrometry; Temperature; *Mono. 27, Supplement 2*.

Thermostat; Ultraviolet-visible; -150 to $+60$ °C; Spectrophotometry; *9316.*

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Thin films; Vacuum; Adsorption; Barium fluoride; Electric hygrometer; Humidity; *J.* **71C** *3-255, 199-207 (1967).*

Thin plates; Bassali's theory; Concentric loading; Circular plates; Deflection; Elasticity; Experimental; Flexure; Point supports; Simplified approximate solutions; *J.* **70C** *4-234, 227-244 (1966).*

Thin wall; Torsion; Tube; Creep; Primary creep; Shear; Shell; Stress analysis; *J.* **71C** *3-256, 209-225 (1967).*

Third law heat; Vapor pressure; Bias of least squares estimators; Coefficient of variation; Correlated estimators; Enthalpy adjustments; Heat of vaporization; High temperature chemistry; Overestimation of standard deviation; *J.* **70A** *6-424, 533-539, (1966).*

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Third spectrum; Corrections to analysis of Au III; Gold; Spectrum of Au III; *J.* **70A** *6-418, 465-466 (1966).*

Thoria; Zirconia; Alumina; Ceramic oxides; Emittance; Error sources; Magnesia; Measurement uncertainties; Spectral emittance; Thermal radiation; *J.* **70A** *5-412, 393-415 (1966).*

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Three-parameter theorem; Argon; Molecular complexity; Molecular thermodynamics; Prigogine's cell theory; Thermodynamic properties; *9386.*

Three-terminal electrode set; Clausius-Mossotti; Density; Dielectric constant; Dilatometer; Function; High pressure; *n*-hexane; Pressure; *J.* **71A** *4-460, 287-292 (1967).*

Threshold; Acoustic cavitation; Alpha-particle-induced cavitation; Cavitation; Cavitation nucleus; Cavitation threshold; Fission-induced cavitation; Neutron-induced cavitation; Radiation-induced cavitation; *J.* **71C** *4-261, 299-312 (1967).*

Threshold; Ultraviolet; Vacuum; Dissociation; Fragment ions; Ionization; Mass spectrometer; Molecule; NO_2; NO_2^+ N_2O^+; Photoionization; *J.* **71A** *5-467, 371-378 (1967).*

Threshold energies; Autoionization; 1,2-dideuteroethylene; Ethylene; Mass spectra; Photoionization; Rydberg; *9281.*

Time; Reference specimens; Dielectric constant; Dissipation factor; Frequency; Fluorinated ethylene-propylene; Humidity; Polycarbonate; Polyethylene; Poly(1,4-cyclohexylenedimethylene terephthalate); Polystyrene; *J.* **71C** *2-251, 119-125 (1967).*

Time and frequency dissemination; VHF; VLF; HF; Noise; Satellite; Synchronization; *TN357.*

Time intervals; Noise, signal; Photomultipliers; Signal noise ratio; Statistical properties; *9232.*

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Time-shared computer; X-ray spectroscopy; Analysis; Arc temperature; Atomic absorption spectrometry; Analog computer; Bibliography; Computer; Electrodeposition; Electron back scatter; Electron probe microanalyzer; Emission spectroscopy; Laser probe; *TN401.*

Time signals; Very low frequency; Broadcast of standard frequencies; High frequency; Low frequency; Standard frequencies; *M236, 1967 Edition.*

Time signals; Very low frequency; Broadcast of standard frequencies; High frequency; Low frequency; Standard frequencies; *9237.*

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Torsion; Tube; Creep; Primary creep; Shear; Shell; Stress analysis; Thin wall; *J.* **71C** *3-256, 209-225 (1967).*

Torsion pendulum; Varying crystallinities; Apparatus; Isothermally crystallized sample; Loss compliance; Loss modulus; Mechanical relaxation; Polychlorotrifluoroethylene; Quenched sample; Storage modulus; Tan δ; *9441.*

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Trace amounts; Cadmium; Dithizone; Silver; Sub-stoichiometric radioisotopic dilution analysis; *9168.*

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Transformer; Voltage-divider; Voltmeter; Alternating-current; Calibration; Direct-current; High-voltage; Ratio; Safety; Standards enclosure; *TN349.*

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Wire bar supports; Bars, concrete reinforcement; Concrete construction, supports; Reinforced concrete construction; Reinforcement bars; *PS7-66.*

Wirtinger; Inequalities; Norms; *J.* **70B** *3-184, 221-231 (1966).*

Wood particleboard; Mat-formed particleboard; Particleboard requirements; Particleboard, wood; *CS236-66.*

Work function; (110) plane; Energy distribution; Field emission; Patch fields; Tungsten; *9424.*

Work function; Adsorption; Chemisorption; Desorption; Dissociation; Field emission microscopy; Kinetic; Nitric oxide; Surface; Surface diffusion; Tungsten; *9421.*

Work function; Energy distribution; Field emission; Patch fields; Single crystal planes; *9423.*

World days service; Radio science; *9189.*

World trade; Developing countries; International standards; Role of government; Role of private enterprise; Technology; *M284.*

$W \cdot \bar{s}_m$; Absorbed dose; Calorimeter; Cavity ionization chamber; Cobalt-60 gamma rays; Comparison; Graphite; *J.* **71C** *1-440, 19-27 (1967).*

X

Xenon; Atomic spectra; Krypton; Photoionization; Vacuum ultraviolet; *9208.*

Xenon; Transport coefficients; Correlations; M-6; Kihara; Exp: 6, Morse; Potential functions; Dilute gases; Neon; Krypton; *TN352.*

X-ray; Barium tetragermanate; Structure; Benitoite; Crystal; *J.* **70A** *5-411, 385-391 (1966).*

X ray; Diffraction; Diffractometer; Neutrons; Simultaneous; Three-circle; *9524.*

X-ray back-reflection; Calcium molybdate; Crystal orientation; Crystallographic groups; Interplanar angles; Physical properties; Scheelite structure; Single crystal; *J.* **70A** *5-410, 379-384 (1966).*

X-ray diffraction; Constants; Crystal; Lattice; Measurements; Powder-patterns; Reference-intensities; Standard; Structure; *Mono. 25, Section 5.*

X-ray diffraction; Divergent x-ray beams; Kossel; Kossel sample preparation; Photographic contrast; Transmission of x rays; *9521.*

X-ray emission; X-ray spectrometers; Electron probe microanalyzer; Wavelengths; *TN406.*

X-ray instrumentation; Divergent x-ray beam; Instrument design; Kossel camera; Kossel method; *J.* **71C** *4-262, 313-318 (1967).*

X-rays; Absorption; Radiation; Spectroscopy; Ultraviolet; *9311.*

X rays; Fiber optics; *9363.*

X-rays; Fibers; Microfocus tubes; Microradiography; Nylon; Polyacrylonitrile; Polyamides; Reflection of x-rays; Soft x-rays; *9488.*

X-ray spectra; Molecular energy levels; Molecules; *9443.*

X-ray spectrochemical analysis; Microanalytical techniques; Solids mass spectrometer; Electron probe microanalyzer; NBS white cast iron sample (SRM 1175); Stainless steel powder metallurgy compact; Optical metallography; Macroanalytical techniques; *M260-12.*

X-ray spectrometers; Electron probe microanalyzer; Wavelengths; X-ray emission; *TN406.*

X-ray spectrometry; Scanning electron microscopy; Electron backscatter; Cathodoluminescence; Electron probe; Microanalysis; *TN278.*

X-ray spectroscopy; Analysis; Arc temperature; Atomic absorption spectrometry; Analog computer; Bibliography; Computer; Electrodeposition; Electron back scatter; Electron probe microanalyzer; Emission spectroscopy; Laser probe; Mass spectroscopy; *TN401.*

X-ray spectroscopy: Electrochemical methods: Electron and optical microscopy: Nuclear methods: Optical spectroscopy: Symposium on trace characterization: Trace characterization: *Mono. 100.*

X-ray wavelength: Absorption: Atomic: Data compilation: Emission: Energy levels: *NSRDS-NBS14.*

X-transitions: Critical phenomena: Critical point: Second order phase transition: Singularities: Pade approximate fluctuations: Opalescence: *M273.*

Y

Yields: Detector: Efficiency: Four-pi: Halpern: Neutron: Photoneutron: Response: *TN416.*

Yield stress: Elastic stress: Heat transfer: Plane strain: Thermal stress: *J.* **70B** *4-188, 265-272 (1966).*

YIG: External tensor permeability: Ferrimagnetic resonance: Ferrites: Garnet: Low magnetic field effects: Permeability: Spin waves: Tensor permeability: *9395.*

Young's modulus: Aluminum oxide: Corundum: Elastic constants: Shear modulus: *J.* **70A** *4-403, 277-280 (1966).*

Young's modulus: Internal friction: Lanthanum titanate: Phase change: Resonance: Strontium titanate: Vacancies: *9447.*

Y-transform: Fourier-transform: Functional transforms: Generalized MacRobert's function: Hankel transform, *K*-transform: Laplace transform, MacRobert's function: *J.* **71B** *1-194, 23-37 (1967).*

Ytterbium, second spectrum: Zeeman effect in Yb II: Analysis of Yb II: Atomic energy levels of Yb II: Classified line of Yb II: Spectrum, Yb II: *J.* **71A** *6-470, 396-545 (1967).*

Z

Zeeman effect: H_2CO: Magnetic hyperfine structure: RF transition: *9412.*

Zeeman effect in Yb II: Analysis of Yb II: Atomic energy levels of Yb II: Classified line of Yb II: Spectrum, Yb II: Ytterbium, second spectrum: *J.* **71A** *6-470, 396-545 (1967).*

Zero-range: Cross section: Differential cross section: ^3H: ^3He: Photodisintegration: *9341.*

Zeros of Legendre polynomials: Gaussian quadrature: Integral equations: Numerical integration: *J.* **70B** *4-186, 249-256 (1966).*

Zinc dibutyldithiocarbamate: Zinc dimethyldithiocarbamate: Accelerators: Far infrared: Natural rubber: Sulfur: Tetramethylthiuram disulfide: Vulcanization: *J.* **71A** *1-432, 19-23 (1967).*

Zinc dimethyldithiocarbamate: Accelerators: Far infrared: Natural rubber: Sulfur: Tetramethylthiuram disulfide: Vulcanization: Zinc dibutyldithiocarbamate: *J.* **71A** *1-432, 19-23 (1967).*

Zirconia: Alumina: Ceramic oxides: Emittance: Error sources: Magnesia: Measurement uncertainties: Spectral emittance: Thermal radiation: Thoria: *J.* **70A** *5-412, 393-415 (1966).*

Zirconium hydrides: Beta zirconium hydrides: Statistical model: *9302.*

ZnS: Electric fields: Ionic crystals: Lattice sums: Point defects: Polarization: NaCl: CsCl: CaF_2: *J.* **71A** *1-428, 1-2 (1967).*

Zone refining: Crystal growth: Fermi surface: Orientation: Potassium: Spark cutting: *J.* **71A** *2-443, 127-132 (1967).*

Zone refining: Fermi surface: Magnetoacoustic absorption: Potassium: Single crystals: *9197.*

ζ_3: ζ_4: Band contours: BF_3: Coriolis force: Force fields: High resolution: Infrared: ν_3: Vibration-rotation: *9268.*

ζ_4: Band contours: BF_3: Coriolis force: Force fields: High resolution: Infrared: ν_3: Vibration-rotation: ζ_3: *9268.*

0.06 Å resolution: Spectrograph: Synchrotron light: Grazing-incidence: 3-meter: Monochromator alignment: *9355.*

1,2-dideuteroethylene: Ethylene: Mass spectra: Photoionization: Rydberg: Threshold energies: Autoionization: *9281.*

1,2-dihydronaphthalene: Degradation: Polymerization: Pyrolysis: Thermal decomposition: Thermal volatilization: *9218.*

1,2-0-isopropylidene-β-L-idofuranose; 2,3-0-isopropylidene-β-D-threo-pentulofuranose: Air pollution studies: Characterization of chemical structures: Disaccharide of d-lyxofuranose: Infrared absorption methods for analysis of carbohydrates: *TN427.*

1-acylamido sugars: Aldofuranoid sugars: Aldopyranoid sugars: Infrared spectra: Absorption spectra: Acyclic sugars: *J.* **71A** *1-437, 53-79 (1967).*

1-*t*-butoxy-2,3,5,6-tetrafluoro-4-trifluoromethylbenzene: Perfluoro-*p*-quinonemethide: Polymerization; Poly-*p*-oxyperfluorobenzylene; Pyrolysis; 2,3,5,6-tetrafluoro-4-trifluoromethylphenol: *J.* **71A** *1-434, 33-41 (1967).*

100 MeV-40 KW LINAC: Clean room: Computers: Counting rooms: Feedback analysis: Optimization of variables 10 MW nuclear reactor: Pneumatic tubes: Radiochemical laboratories: 14 MeV neutron generator: *9154.*

(110) plane; Energy distribution; Field emission; Patch fields; Tungsten; Work function; *9424.*

14 MeV neutron generator: 100 MeV-40 KW LINAC: Clean room: Computers: Counting rooms: Feedback analysis: Optimization of variables 10 MW nuclear reactor: Pneumatic tubes: Radiochemical laboratories: *9154.*

14 MeV neutrons: ^{165}Ho: Black nucleus model: Cryogenic target: Coupled-channel calculation: Nuclear alignment: Nuclear deformation: Optical model: Van de Graaff: *9362.*

^{165}Ho: Black nucleus model: Cryogenic target: Coupled-channel calculation: Nuclear alignment: Nuclear deformation: Optical model: Van de Graaff: 14 MeV neutrons: *9362.*

2,3,5,6-tetrafluoro-4-trifluoromethylphenol; 1-*t*-butoxy-2,3,5,6-tetrafluoro-4-trifluoromethylbenzene: Perfluoro-*p*-quinonemethide: Polymerization: Poly-*p*-oxyperfluorobenzylene; Pyrolysis: *J.* **71A** *1-434, 33-41 (1967).*

2,3-0-isopropylidene-β-D-threo-pentulofuranose: Air pollution studies: Characterization of chemical structures: Disaccharide of d-lyxofuranose: Infrared absorption methods for analysis of carbohydrates: Naturally occurring monosaccharides and 6-deoxy sugars: *TN427.*

2-methylbutane: 3-methylpentane: Ion-molecule reaction: Liquid phase photolysis: Liquid phase radiolysis: *9392.*

200 Watts (30 °K): Design: Expansion turbine: Gas bearings: Helium refrigeration: Performance: 9800 RPS: *9151.*

^3H: ^3He: Photodisintegration: Zero-range: Cross section: Differential cross section: *9341.*

^3He: Photodisintegration: Zero-range: Cross section: Differential cross section: ^3H: *9341.*

3j coefficient: 6j coefficient: 9j coefficient: Clebsch-Gordan coefficients: Fortran program: Wigner coefficients: Quantum theory of angular momentum: *TN409.*

3-manifold: 3-sphere: Free group: Handlebody: Homeomorphism: Simply connected: Topology: *J.* **71B** *2&3-197, 53-56 (1967).*

3-meter: Monochromator alignment: 0.06 Å resolution: Spectrograph: Synchrotron light: Grazing-incidence: *9355.*

3-methylpentane: Ion-molecule reaction: Liquid phase photolysis: Liquid phase radiolysis: 2-methylbutane: *9392.*

3-sphere: Free group: Handlebody: Homeomorphism: Simply connected: Topology: 3-manifold: *J.* **71B** *2&3-197, 53-56 (1967).*

337-micron CN laser: Laser: Radiation: Rotational level: Vibrational state: *9163.*

405 representation: Higher symmetry scheme: λ quark content: Nonet of 2^{-+} mesons: Schwinger mass formula: $SU(6)_W$: *9332.*

4-3m symmetry; Angular dependence; Hexadecapole; Hexadecapole transitions; Phonon interactions; Saturation factor; *9357*.

6j coefficient; 9j coefficient; Clebsch-Gordan coefficients; Fortran program; Wigner coefficients; Quantum theory of angular momentum; 3j coefficient; *TN409*.

−150 to +60 °C; Spectrophotometry; Thermostat; Ultraviolet-visible; *9316*.

9j coefficient; Clebsch-Gordan coefficients; Fortran program; Wigner coefficients; Quantum theory of angular momentum; 3j coefficient; 6j coefficient; *TN409*.

9800 RPS; 200 Watts (30 °K); Design; Expansion turbine; Gas bearings; Helium refrigeration; Performance; *9151*.

APPENDIX A. LIST OF DEPOSITORY LIBRARIES IN THE UNITED STATES

ALABAMA

- Auburn: Auburn University Library.
- Birmingham:
    - Howard College, Harwell G. Davis Library.
    - Birmingham Southern College, M. Paul Phillips Library.
    - Public Library.
    - Sanford Library.
- Florence: Florence State College, Collier Library.
- Gadsen: Gadsen Public Library.
- Huntsville: University of Alabama in Huntsville Library.
- Jacksonville: State Teachers College Library.
- Maxwell A.F. Base: Air University Library.
- Mobile: Mobile Public Library.
- Mobile (Spring Hill): Spring Hill College, Thomas Byrne Memorial Library.
- Montgomery:
    - Department of Archives and History Library.
    - Supreme Court Library of Alabama.
- Normal: Alabama Agricultural and Mechanical College, Carnegie Library.
- St. Bernard: St. Bernard College Library.
- Troy: Troy State College Library.
- Tuskegee Institute: Hollis Burke Frissell Library.
- University: University of Alabama Library—REGIONAL.

ALASKA

- Anchorage:
    - Anchorage Community College Library.
    - Anchorage Methodist University Library.
- College: University of Alaska Library.
- Juneau: Alaska State Library.

AMERICAN SAMOA

- Pago Pago: Library of American Samoa.

ARIZONA

- Flagstaff:
    - Arizona State College Library.
    - Northern Arizona University.
- Phoenix:
    - Department of Library and Archives—REGIONAL.
    - Phoenix Public Library.
- Tempe: Arizona State University, Matthews Library.
- Thatcher: Eastern Arizona Junior College Library.
- Tucson: University of Arizona Library—REGIONAL.
- Yuma: Yuma City-County Library.

ARKANSAS

- Arkadelphia: Ouachita Baptist College Library.
- Batesville: Arkansas College Library.
- Clarksville: College of the Ozarks Library.
- College Heights: Arkansas Agricultural and Mechanical College Library.
- Conway: Hendrix College, The H. F. Buhler Library.
- Fayetteville: University of Arkansas Library.
- Little Rock:
    - Little Rock Public Library.
    - Supreme Court Library.
- Magnolia: Southern State College, J. M. Peace Library.
- Russellville: Arkansas Polytechnic College Library.
- Searcy: Harding College Beaumont Memorial Library.
- State College: Arkansas State College Library.

CALIFORNIA

- Anaheim: Anaheim Public Library.
- Arcata: Humboldt State College Library.
- Bakersfield: Kern County Free Library.
- Berkeley:
    - Earl Warren Legal Center Library of Univ. of California at Berkeley.
    - University of California Library.
- Chico: Chico State College Library.
- Claremont: Pomona College, Honnold Library.
- Culver City: Culver City Library.
- Davis: University of California Library.
- Downey: Downey City Library.
- Fresno:
    - Fresno County Free Library.
    - Fresno State College Library.
- Fullerton: California State College at Fullerton Library.
- Gardena: Gardena Library.
- Goleta: University of California at Santa Barbara Library.
- Hayward: California State College Library at Hayward.
- Inglewood: Inglewood Public Library.
- Irvine: University of California at Irvine Library.
- La Jolla: University of California at La Jolla Library.
- Lancaster: Antelope Valley College Library.
- Long Beach:
    - California State College Library at Long Beach.
    - Public Library.
- Los Angeles:
    - California State College at Los Angeles, John F. Kennedy Memorial Library.
    - Los Angeles County Law Library.
    - Los Angeles Public Library.
    - Loyola University of Los Angeles Library.
    - Occidental College Library.
    - Pepperdine College Library.
    - University of California at Los Angeles Library.
    - University of California, School of Law Library.
    - University of Southern California Library.
- Lynwood: Lynwood Library.
- Marysville: Yuba College District Library.
- Menlo Park: Dept. of Interior, Geological Survey Library.
- Montebello: Rio Hondo Regional Library.
- Monterey: Naval Postgraduate School Library.
- Monterey Park: Bruggemeyer Memorial Library.
- Northridge: San Fernando Valley State College Library.
- Oakland: Oakland Public Library.
- Orange: Orange County Free Library.
- Pasadena:
    - California Institute of Technology Library.
    - Pasadena Public Library.
- Pleasant Hill: Contra Costa County Library.
- Redding: Shasta County Free Library.
- Redlands: University of Redlands Library.
- Reseda: West Valley Regional Branch Library.
- Richmond: Richmond Public Library.
- Riverside:
    - Riverside Public Library.
    - University of California at Riverside Library.
- Sacramento:
    - California State Library—REGIONAL.
    - City Free Library.
    - Sacramento County Law Library.
    - Sacramento State College Library.
- San Bernardino: San Bernardino College Library.
- San Diego:
    - San Diego County Library.
    - San Diego Public Library.
    - San Diego State College Library.
- San Francisco:
    - Mechanics Institute Library.
    - San Francisco Public Library.
    - San Francisco State College, Social Science and Business Library.

Univ. of San Francisco, Richard A. Gleeson Library.
San Jose: San Jose State College Library.
San Leandro: San Leandro Community Library Center.
Santa Ana: Santa Ana Public Library.
Santa Clara: University of Santa Clara, Michel Orradre Library.
Santa Cruz: University of California at Santa Cruz, University Library.
Santa Rosa: Santa Rosa Public Library.
Stanford: Stanford University Libraries.
Stockton: Stockton Free Public Library.
Thousands Oaks. California Lutheran College Library.
Turlock: Stanislaus State College Library.
Walnut: Mt. San Antonio College Library.
West Covena: West Covena Library.
Whittier: Whittier College Library.

CANAL ZONE

Balboa Heights: Canal Zone Library.

COLORADO

Alamosa: Adams State College Library.
Boulder: University of Colorado Library—REGIONAL.
Colorado Springs: Colorado College, Charles Leaming Tutt Library.
Denver:
  Colorado State Library.
  Dept. of Interior, Bur. of Reclamation Library.
  Public Library—REGIONAL.
  Regis College Library.
  University of Denver, Mary Reed Library.
Fort Collins: Colorado State University Library.
Golden: Colorado School of Mines Library.
Greeley: Colorado State College.
Gunnison: Western State College Library.
La Junta:
  Otero Junior College, Wheeler Library.
Pueblo:
  McClelland Public Library.
  Southern Colorado State College Library.
U.S. Air Force Academy: Academy Library.

CONNECTICUT

Bridgeport: Pridgeport Public Library.
Bristol: Public Library.
Hartford:
  Connecticut State Library—REGIONAL.
  Hartford Public Library.
  Trinity College Library.
Middletown: Wesleyan University, Olin Library.
Mystic: Mystic Seaport Library.
New Haven: Yale University Library.
New London:
  Connecticut College, Palmer Library.
  U.S. Coast Guard Academy Library.
Storrs: University of Connecticut Library.
Waterbury: Silas Branson Library.

DELAWARE

Dover:
  Delaware State College Library.
  State Law Library.
Newark: University of Delaware, Morris Library.
Wilmington: Wilmington Institute Free Library.

DISTRICT OF COLUMBIA

Washington:
  Bureau of the Budget Library, Exec. Office of the President.
  Civil Service Commission Library.
  Department of Commerce Library.
  Department of Health, Education, and Welfare Library.
  Department of Interior Central Library.
  Department of Interior, Geological Survey Library.
  Department of Justice Main Library.
  Department of State Library.
  National Agricultural Library.
  National War College Library.
  Navy Department Library.
  Navy Department, Office of Judge Advocate General Library.
  Post Office Department Library.
  Public Library.
  Treasury Department Library.

FLORIDA

Boca Raton: Florida Atlantic University Library.
Coral Gables: University of Miami Library.
Daytona Beach: Volusia County Public Libraries.
De Land: John B. Stetson University, Sampson Library.
Gainesville: University of Florida Library—REGIONAL.
Jacksonville:
  Jacksonville Public Library.
  Jacksonville University Library.
Lakeland: Park Trammell Public Library.
Leesburg: Lake-Sumter Junior College Library.
Melbourne: Brevard Engineering College Library.
Miami: Miami Public Library.
Orlando: Florida Technological University.
Palatka: St. Johns River Junior College Library.
Pensacola: University of West Florida.
Tallahassee:
  Florida Agricultural and Mechanical University Library.
  Florida State Library.
  Florida State University Library.
Tampa:
  Tampa Public Library.
  University of South Florida Library.
  University of Tampa Library.
Winter Park: Rollins College, Mills Memorial Library.

GEORGIA

Albany: Albany Public Library.
Americus: Georgia Southwestern College.
Athens: University of Georgia Libraries.
Atlanta:
  Atlanta Public Library.
  Atlanta University, Trevor Arnett Library.
  Emory University, Asa Griggs Candler Library.
  Georgia Institute of Technology, Price Gilbert Memorial Library.
  Georgia State Library.
Augusta: Augusta College Library.
Brunswick: Brunswick Public Library.
Carrollton: West Georgia College Library.
Dahlonega: North Georgia College Library.
Macon: Mercer University Library.
Milledgeville: Woman's College of Georgia Library.
Savannah: Savannah Public Library.
Statesboro: Georgia Southern College Library.
Valdosta: Valdosta State College Library.

GUAM

Agana: Nieves M. Flores Memorial Library.

HAWAII

Hilo: University of Hawaii, Hilo Campus Library.
Honolulu:
  Chaminade College Library.
  Library of Hawaii.
  Municipal Reference Library.
  University of Hawaii Library.
Laie: Church College of Hawaii Library.
Wailuku: Maui County Library.

IDAHO

Boise:
  Boise College Library.
  Boise Public Library.

  - Idaho State Law Library.
- Caldwell: The College of Idaho, Strahorn Memorial Library.
- Moscow: University of Idaho Library—REGIONAL.
- Pocatello: Idaho State University Library.
- Rexburg: Ricks College Library.

ILLINOIS

- Bloomington: Illinois Wesleyan University Libraries.
- Carbondale: Southern Illinois University Library.
- Champaign: University of Illinois Law Library.
- Carlinville: Blackburn College Library.
- Charleston: Eastern Illinois University, Booth Library.
- Chicago:
  - Chicago National Historical Museum Library.
  - Chicago Public Library.
  - Chicago Teachers College Library.
  - Chicago Teachers College, North Campus Library.
  - Illinois Teachers College.
  - John Crerar Library.
  - Loyola University Library.
  - Newbury Library.
  - University of Chicago Law Library.
  - University of Chicago Libraries.
  - University of Illinois, Chicago Circle Campus Library.
- Decatur: Decatur Public Library.
- De Kalb: Northern Illinois University Library.
- Edwardsville: Southern Illinois University, Edwardsville Service Center Library.
- Elsah: Principia College, Marshall Brooks Library.
- Evanston: Northwestern University Library.
- Freeport: Freeport Public Library.
- Galesburg: Galesburg Public Library.
- Jacksonville: McMurray College Library.
- Kankakee: Olivet Nazarene College Library.
- Lake Forest: Lake Forest College, Donnelley Library.
- Lisle: St. Procopius College Library.
- Lockport: Lewis College of Science and Technology Library.
- Macomb: Western Illinois University Memorial Library.
- Monmouth: Monmouth College Library.
- Normal: Illinois State Normal University Library.
- Oak Park: Oak Park Public Library.
- Peoria:
  - Bradley University Library.
  - Peoria Public Library.
- River Forest: Osary College Library.
- Rock Island: Rock Island Public Library.
- Rockford: Public Library.
- Springfield: Illinois State Library—REGIONAL.
- Urbana: University of Illinois Library.
- Wheaton: Wheaton College Library.
- Woodstock: Woodstock Public Library.

INDIANA

- Anderson: Anderson College, Charles E. Wilson Library.
- Bloomington: Indiana University Library.
- Crawfordsville: Wabash College Library.
- Evansville: Evansville Public Library.
- Fort Wayne:
  - Indiana-Purdue University Regional Campus Library.
  - Public Library.
- Gary:
  - Gary Public Library.
  - Indiana University Northwest Campus Library.
- Greencastle: De Pauw University Library.
- Hammond: Hammond Public Library.
- Hanover: Hanover College Library.
- Huntington: Huntington College Library.
- Indianapolis:
  - Butler University, Irwin Library.
  - Indiana State Library—REGIONAL.
  - Indianapolis Public Library.
- Jeffersonville: Indiana University, Southeastern Campus Library.
- Lafayette: Purdue University Library.
- Muncie:
  - Ball State Teachers College Library.
  - Public Library.
- Notre Dame: University of Notre Dame Library.
- Rensselaer: St. Joseph's College Library.
- Richmond:
  - Earlham College, Lilly Library.
  - Morrison-Reeves Library.
- South Bend: Indiana University, South Bend-Mishawaka Campus Library.
- Terre Haute: Indiana State College Library.
- Valparaiso: Valparaiso University Library.

IOWA

- Ames: Iowa State University of Science and Technology Library.
- Cedar Falls: State College of Iowa Library.
- Council Bluffs: Free Public Library.
- Des Moines:
  - Iowa State Traveling Library.
  - Public Library.
- Dubuque: Carnegie Stout Free Public Library.
- Fairfield: Parsons College Library Branch of Fairfield Free Public Library.
- Grinnell: Grinnell College Library.
- Iowa City: State University of Iowa Library—REGIONAL.
- Lamoni: Graceland College Library.
- Mount Vernon: Cornell College Library.
- Sioux City: Public Library.
- Spencer: Spencer Public Library.

KANSAS

- Atchison: St. Benedict's College, The Abbey Library.
- Baldwin City: Baker University Library.
- Emporia: Kansas State Teachers College, William Allen White Library.
- Hays: Fort Hays Kansas State College, Forsyth Library.
- Hutchinson: Hutchinson Public Library.
- Lawrence: University of Kansas Library.
- Manhattan: Kansas State University Library.
- Pittsburgh: Kansas State College of Pittsburg, Porter Library.
- Salina: Kansas Wesleyan University Library.
- Topeka:
  - Kansas State Historical Society Library.
  - Kansas State Library.
- Wichita: Wichita State University Library.

KENTUCKY

- Ashland: Ashland Public Library.
- Barbourville: Union College, Abigal E. Weeks Memorial Library.
- Bowling Green: Western Kentucky State Teachers College Library.
- Danville: Centre College Library.
- Elizabethtown: Oxbow Regional Library.
- Frankfort: State Law Library.
- Lexington: University of Kentucky Library.
- Louisville:
  - Louisville Free Public Library.
  - University of Louisville Library.
- Morehead: Morehead State College, Johnson Camden Library.
- Murray: Murray State College Library.
- Owensboro: Kentucky Wesleyan College Library.
- Pikeville: Pikeville College Library.
- Richmond: Eastern Kentucky University Library.

LOUISIANA

- Baton Rouge:
  - Louisiana State University Law Library.
  - Louisiana State University Library—REGIONAL.

Southern University Library.
Hammond: Southeastern Louisiana College Library.
Lafayette: University of Southwestern Louisiana Library.
Lake Charles: McNeese State College Library.
Monroe: Northeast Louisiana State College, Sandel Library.
Natchitoches: Northwestern State College of Louisiana.
New Orleans:
    Law Library of Louisiana.
    Louisiana State University Library.
    Loyola University Library.
    New Orleans Public Library.
    Southern University in New Orleans Library.
    Tulane University, Howard-Tilton Memorial Library.
Ruston: Louisiana Polytechnic Institute Library—REGIONAL.
Shreveport: Shreve Memorial Library.
Thibodaux: Francis T. Nicholls State College Library.

MAINE

Augusta: Maine State Library.
Bangor: Bangor Public Library.
Brunswick: Bowdoin College Library.
Lewiston: Bates College Library.
Orono: University of Maine Library—REGIONAL.
Portland:
    Portland Public Library.
    University of Maine Law Library.
Springvale: Nasson College Library.
Waterville: Colby College Library.

MARYLAND

Annapolis:
    Maryland State Library.
    U.S. Naval Academy Library.
Baltimore:
    Enoch Pratt Free Library.
    Goucher College Library.
    Johns Hopkins University Library.
    Morgan State College Library.
    Peabody Institute Library.
Bethesda: Montgomery County Department of Public Libraries.
Chestertown: Washington College, George Avery Bunting Library.
College Park: University of Maryland Library—REGIONAL.
Germantown: Atomic Energy Commission Library.
Salisbury: Salisbury State College Library.
Westminster: Western Maryland College Library.

MASSACHUSETTS

Amherst:
    Amherst College Library.
    University of Massachusetts, Goodell Library.
Boston:
    Boston Athenaeum Library.
    Boston College Libraries.
    Northeastern University, Dodge Library.
    Public Library of the City of Boston.
    State Library of Massachusetts—REGIONAL.
Brookline: Public Library.
Cambridge:
    Harvard College Library, Serials Division.
    Massachusetts Institute of Technology Library.
Lowell: Lowell Technological Institute Library.
Lynn: Lynn Public Library.
Medford: Tufts University Library.
New Bedford: Public Library.
North Dartmouth: Southeastern Massachusetts Technological Institute Library.
North Easton: Stonehill College, Cushing-Martin Library.
Waltham: Brandeis University Library.
Wellesley Wellesley College Library.
Wenham: Gordon College, Winn Library.
Williamstown: Williams College Library.
Worcester:
    American Antiquarian Society Library.
    Free Public Library.

MICHIGAN

Albion: Albion College Library.
Allendale: Grand Valley State College Library.
Alma: Alma College, Monteith Library.
Ann Arbor: University of Michigan, General Library.
Battle Creek: Willard Library.
Benton Harbor: Benton Harbor Public Library.
Bloomfield Hills: Cranbrook Institute of Science Library.
Dearborn: Henry Ford Community College Library.
Detroit:
    Detroit Public Library—REGIONAL.
    Marygrove College Library.
    Mercy College Library.
    University of Detroit Library.
    Wayne County Public Library.
    Wayne State University Library.
East Lansing: Michigan State University Library.
Escanaba: Michigan State Library, Upper Peninsula Branch.
Flint: Flint Junior College Library.
Grand Rapids: Grand Rapids Public Library.
Houghton: Michigan College of Mining and Technology Library.
Kalamazoo:
    Public Library.
    Western Michigan University, Dwight B. Waldo Library.
Lansing: Michigan State Library—REGIONAL.
Livonia: Schoolcraft College Library.
Marquette: Northern Michigan College, Olson Library.
Mt. Pleasant: Central Michigan, University Library.
Muskegon: Hackley Public Library.
Petoskey: North Central Michigan College Library.
Port Huron: Port Huron Public Library.
Rochester: Oakland University Library.
Saginaw: Hoyt Public Library.
Traverse City: Northwestern Michigan College, Mark Osterlin Library.
University Center: Delta College Library.
Ypsilanti: Eastern Michigan University Library.

MINNESOTA

Bemidji: Bemidji State College Library.
Collegeville: St. Johns University Library.
Duluth: Duluth Public Library.
Mankato: Mankato State College Library.
Minneapolis:
    Public Library.
    University of Minnesota Library—REGIONAL.
Moorhead: State College Library.
Morris: University of Minnesota, Morris Library.
Northfield:
    Carleton College Library.
    St. Olaf College Library.
St. Cloud: St. Cloud State College Library.
St. Paul:
    Minnesota Historical Society Library.
    Minnesota State Law Library.
    St. Paul Public Library.
Saint Peter: Gustavus Adolphus College Library.
Stillwater: Stillwater Public Library.
Willmar: Kandiyohi County-Willmar Library.

MISSISSIPPI

Columbus: Mississippi State College for Women, J. C. Fant Memorial Library.
Hattiesburg: University of Southern Mississippi Library.

Jackson:
    Millsaps College, Millsaps-Wilson Library.
    Mississippi Library Commission.
    Mississippi State Library.
State College: Mississippi State University, Mitchell Memorial Library.
University: University of Mississippi Library.

MISSOURI

Cape Girardeau: Kent Library Southeast Missouri State College.
Columbia: University of Missouri Library.
Fayette: Central Methodist College Library.
Fulton: Westminster College Library.
Hannibal: Free Public Library.
Jefferson City:
    Lincoln University Library.
    Missouri State Library.
    Missouri Supreme Court Library.
Joplin: Missouri Southern College Library.
Kansas City:
    Kansas City Public Library.
    Rockhurst College Library.
    University of Kansas City Library.
Kirkville: Northeast Missouri State Teachers College Library.
Liberty: William Jewell College Library.
Rolla: School of Mines & Metallurgy Library.
St. Joseph: St. Joseph Public Library.
St. Louis:
    St. Louis Public Library.
    St. Louis University Library.
    University of Missouri at St. Louis Library.
    Washington University Libraries.
Springfield:
    Drury College Library.
    Southwest Missouri State College Library.
Warrensburg: Central Missouri State College Library.

MONTANA

Billings: Eastern Montana College Library.
Bozeman: Montana State College Library.
Butte: Montana School of Mines Library.
Helena: Historical Society of Montana Library.
Missoula: State University of Montana Library—REGIONAL.

NEBRASKA

Blair: Dana College Library.
Crete: Whitin Library of Doane College.
Fremont: Midland College Library.
Hastings: Hastings Public Library.
Kearney: Nebraska State Teachers College Library.
Lincoln:
    Nebraska State Library.
    University of Nebraska Libraries.
Omaha:
    Creighton University, Alumni Library.
    Municipal University of Omaha Library.
    Omaha Public Library.
Scottsbluff: Scottsbluff Public Library.

NEVADA

Carson City: Nevada State Library.
Las Vegas: University of Nevada, Southern Regional Division Library.
Reno: University of Nevada Library—REGIONAL.

NEW HAMPSHIRE

Concord: New Hampshire State Library.
Durham: University of New Hampshire Library.
Hanover: Dartmouth College Library.
Manchester:
    City Library.
    St. Anselm's College, Geisel Library.

NEW JERSEY

Atlantic City: Free Public Library.
Bayonne: Free Public Library.
Bloomfield: Free Public Library.
Camden: Camden Free Public Library.
Convent Station: Santa Maria Library of College of St. Elizabeth.
East Orange: East Orange Public Library.
Elizabeth: Public Library.
Glassboro: Glassboro State College, Savitz Library.
Hackensack: Johnson Free Public Library.
Jersey City:
    Free Public Library.
    Jersey City State College Library.
Madison: Drew University, Rose Memorial Library.
New Brunswick:
    Free Public Library.
    Rutgers University Library.
Newark: Public Library—REGIONAL.
Passaic: Passaic Public Library.
Princeton: Princeton University Library.
Rutherford: Fairleigh Dickinson University Library.
South Orange: Seton Hall University Library.
Teaneck: Fairleigh Dickinson University Library.
Toms River: Ocean County College Library.
Trenton:
    Division of State Library, Archives and History—Department of Education.
    Free Public Library.
West Long Branch: Monmouth College, Guggenheim Memorial Library.
West New York: West New York Free Public Library.
Woodbridge: The Free Public Library of Woodbridge.

NEW MEXICO

Albuquerque: University of New Mexico.
Las Vegas: New Mexico Highlands University, Rodgers Library.
Portales: Eastern New Mexico University Library.
Santa Fe:
    New Mexico State Law Library.
    New Mexico State Library, State Library Extension Service—REGIONAL.
University Park: New Mexico State University Library.

NEW YORK

Albany:
    New York State Library—REGIONAL.
    State University of New York at Albany Library.
Binghampton: Harpur College Library.
Brooklyn:
    Brooklyn College Library.
    Brooklyn Public Library.
    Polytechnic Institute Library.
    Pratt Institute Library.
    State University of New York, Downstate Medical Center Library.
Buffalo:
    Buffalo and Erie County Public Library.
    Buffalo and Erie County Public Library, Grosvenor Reference Division.
    State University of New York at Buffalo, Lockwood Memorial Library.
Canton: St. Lawrence University Library.
Corning: Corning Community College Library.
Cortland: State University College Library.
Elmira: Elmira College Library.
Farmingdale: State University Agricultural and Technical Institute Library.
Flushing: Queens College Library.
Garden City: Adelphia University Library.
Greenvale: C. W. Post College Library.
Hamilton: Colgate University Library.
Hempstead:
    Hofstra University Library.
    Nassau Library System.

- Ithaca:
  - Albert R. Mann Library, New York State Colleges of Agriculture and Home Economics.
  - Cornell University Library.
- Jamaica:
  - Queens Borough Public Library.
  - St. Johns University Library.
- Kings Point: U.S. Merchant Marine Academy Library.
- Mount Vernon Public Library.
- New Paltz: State University College Library.
- New York City:
  - College of the City New York Library.
  - College of Insurance Library.
  - Columbia University Library.
  - Cooper Union Library.
  - Fordham University Library.
  - New York Law Institute Library.
  - New York Public Library (Astor Branch).
  - New York Public Library (Lenox Branch).
  - New York University, University Heights Library.
  - State University of New York, Maritime College Library.
- Newburgh: Newburgh Free Library.
- Oakdale: Adelphi Suffolk College Library.
- Oneonta: State University College Library.
- Oswego: State University College Library.
- Potsdam:
  - Clarkson College of Technology Library.
  - State University College Library.
- Poughkeepsie: Vassar College Library.
- Rochester:
  - Rochester Public Library.
  - University of Rochester Library.
- St. Bonaventure: St. Bonaventure College Library.
- Saratoga Springs: Skidmore College Library.
- Schnectady: Union College Library.
- Staten Island: Wagner College, Horrmann Library, Grymes Hill.
- Stony Brook: State University of New York Library.
- Syracuse: Syracuse University Library.
- Troy: Troy Public Library.
- Utica: Utica Public Library.
- West Point: U.S. Military Academy.
- Yonkers: Yonkers Public Library.

NORTH CAROLINA

- Asheville: Asheville-Biltmore College Library.
- Boone: Appalachian State Teachers College, Dauphin Disco Dougherty Memorial Library.
- Buies Creek: Campbell College, Carrie Rich Memorial Library.
- Chapel Hill: University of North Carolina Library—REGIONAL.
- Charlotte:
  - Public Library of Charlotte & Mecklenburg Co.
  - Queens College Library.
  - University of North Carolina at Charlotte, Atkins Library.
- Cullowhee: Western Carolina College Library.
- Davidson: Library of Davidson College.
- Durham: Duke University Library.
- Greensboro:
  - Agricultural and Technical College Library.
  - Univ. of N. Carolina at Greensboro, Walter Clinton Jackson Library.
- Greenville: East Carolina College Library.
- Murfreesboro: Chowan College Library.
- Pembroke: Pembroke State College Library.
- Raleigh:
  - D. H. Hill Library of North Carolina State College.
  - North Carolina State Library.
- Salisbury: Catawba College Library.
- Wilmington: Wilmington College Library.
- Wilson: Atlantic Christian College, Clarence L. Hardy Library.
- Winston-Salem:
  - Public Library of Winston-Salem and Forsyth County.
  - Wake Forest College Library.

NORTH DAKOTA

- Bismarck:
  - State Historical Library.
  - State Law Library.
- Fargo:
  - Fargo Public Library:
  - North Dakota State University of Agriculture and Applied Sciences Library.
- Grand Forks: University of North Dakota Library.
- Minot: State Teachers College Library.
- Richardton: Assumption Abbey Jr. College Library.
- Valley City: State Teachers College Library.

OHIO

- Ada: Ohio Northern University, J. P. Taggart Library.
- Akron:
  - Akron Public Library.
  - University of Akron Library.
- Alliance: Mt. Union College Library.
- Ashland: Ashland College Library.
- Athens: Ohio University Library.
- Bluffton: Musselman Library of Bluffton College.
- Bowling Green: Bowling Green State University Library.
- Cincinnati:
  - Public Library of Cincinnati and Hamilton County.
  - University of Cincinnati Library.
- Cleveland:
  - Cleveland Public Library.
  - Cleveland State University Library.
  - Freiberger Library of Western Reserve University.
  - John Carroll University, Grasselli Library.
- Columbus:
  - Columbus Public Library.
  - Ohio State Library—REGIONAL.
  - Ohio State University Library.
- Dayton:
  - Dayton and Montgomery County Public Library.
  - Miami University-Ohio State University, Dayton Campus Library.
- Delaware: Charles Slocum Library of Ohio Wesleyan University.
- Elyria: Elyria Public Library.
- Gambier: Kenyon College Library.
- Granville: Denison University Library.
- Hiram: Hiram College Library.
- Kent: Kent State University Library.
- Marietta: Marietta College Library.
- New Concord: Muskingum College Library.
- Oberlin: Oberlin College Library.
- Oxford: Miami University Library.
- Portsmouth: Free Public Library.
- Springfield: Warder Public Library.
- Steubenville: Carnegie Library.
- Tiffin: Heidelberg College Library.
- Toledo:
  - Toledo Public Library.
  - University of Toledo Library.
- Van Wert: Brumback Library of Van Wert County.
- Youngstown: Youngstown Public Library.
- Wooster: College of Wooster, Andrews Library.

OKLAHOMA

- Ada: East Central State Teachers College Library.
- Alva: Northwestern State Teachers College Library.
- Bartlesville: Dept. of Interior, Region IV, Bur. of Mines Library.
- Durant: Southeastern State College Library.
- Edmond: Central State College, Max Chambers Library.
- Enid: Public Library of Enid and Garfield Library.
- Langston: Langston Universinty Library.

Norman: University of Oklahoma Library.
Oklahoma City:
    Oklahoma City University Library.
    Oklahoma State Library—REGIONAL.
Shawnee: Oklahoma Baptist University Library.
Stillwater: Oklahoma State University Library.
Tahlequah: Northeastern State Teachers College Library.
Tulsa:
    Tulsa City-County Library Commission.
    University of Tulsa Library.
Weatherford: Southwestern State College Library.

OREGON

Ashland: Southern Oregon College of Education Library.
Corvallis: Oregon State University Library.
Eugene: University of Oregon Library.
Forest Grove: Pacific University Library.
La Grande: Eastern Oregon College Library.
McMinnville: Linfield College, Northrup Library.
Portland:
    Dept. of Interior, Bonneville Power Admin. Library.
    Library Association of Portland.
    Portland State College Library.
    Reed College Library.
Salem: Oregon State Library.

PENNSYLVANIA

Allentown: Muhlenberg College Library.
Bethlehem: Lehigh University Library.
Bradford: Carnegie Public Library.
Carlisle: Dickenson College Library.
Collegeville: Ursinus College Library.
East Stroudsburg: East Stroudsburg State College.
Erie: Erie Public Library.
Greenville: Thiel College, Langenheim Memorial Library.
Harrisburg: Pennsylvania State Library.
Haverford: Haverford College Library.
Hazleton: Hazleton Public Library.
Huntingdon: Juniata College Library.
Johnstown: Cambria Public Library.
Indiana: Indiana State College Library.
Lancaster: Franklin and Marshall College, Fackenthal Library.
Lewisburg: Bucknell University Library.
Meadville: Allegheny College Library.
Millersville: Millersville State College Library.
New Castle: New Castle Free Public Library.
Philadelphia:
    Drexel Institute of Technology Library.
    Free Library of Philadelphia.
    Temple University, Sullivan Memorial Library.
    University of Pennsylvania Library.
Pittsburgh:
    Allegheny Regional Branch Library.
    Carnegie Library of Pittsburgh.
    Dept. of Interior, Region V, Bur. of Mines Library.
    University of Pittsburgh Library.
Reading: Reading Public Library.
Scranton: Scranton Public Library.
Slippery Rock: Slippery Rock State College Library.
Swarthmore: Swarthmore College Library.
University Park: Pennsylvania State University Library.
Villanova: Villanova University Law Library.
Warren: Warren Library Association.
Washington: Memorial Library of Washington and Jefferson College.
Waynesburg: Waynesburg College Library.
Wilkes-Barre: Kings College Library.
Williamsport: James V. Brown Library.
York: York Junior College Library.

PUERTO RICO

Mayaguez: University of Puerto Rico, College of Agriculture and Mechanical Arts Library.
Rio Piedras: University of Puerto Rico General Library.

RHODE ISLAND

Kingston: University of Rhode Island Library.
Newport: Naval War College Libraries.
Providence:
    Brown University Library.
    Providence Public Library.
    Rhode Island College Library.
    Rhode Island State Library.
Westerly: Westerly Public Library.

SOUTH CAROLINA

Charleston:
    Charleston College Library.
    The Citadel Library.
Clemson: Clemson College Library.
Columbia:
    South Carolina State Library.
    University of South Carolina Library.
Greenville:
    Furman University Library.
    Greenville County Library.
Orangeburg: South Carolina State College Library.
Rock Hill: Carnegie Library of Winthrop College.

SOUTH DAKOTA

Aberdeen: Northern State Teachers College Library.
Brookings: South Dakota State University, Lincoln Memorial Library.
Pierre: South Dakota State Library Commission.
Rapid City:
    Rapid City Public Library.
    South Dakota School of Mines & Tech. Library.
Sioux Falls: Carnegie Free Public Library.
Spearfish: Black Hills Teachers College Library.
Vermillion: University of South Dakota Library.
Yankton: Yankton College Library.

TENNESSEE

Chattanooga: Chattanooga Public Library.
Clarksville: Austin Peay State College Library.
Columbia: Maury County Public Library.
Jefferson City: Carson-Newman College, Maples Library.
Johnson City: East Tennessee State University Library.
Knoxville: University of Tennessee Library.
Martin: University of Tennessee Library—Martin Branch.
Memphis:
    Cossitt Reference Library.
    Memphis State University Library.
Murfreesboro: Middle Tennessee State College Library.
Nashville:
    Fisk University Library.
    Joint University Libraries.
    Nashville Public Library.
    State Library Division, Tennessee State Library and Archives.
Sewanee: University of the South Library.

TEXAS

Abilene: Hardin Simmons University Library.
Arlington: Arlington State College library.
Austin:
    Texas State Library—REGIONAL.
    University of Texas, Law Library.
    University of Texas Library.
Beaumont: Lamar State College of Technology Library.
Brownwood: Howard Payne College, Walker Memorial Library.
Canyon: West Texas State University Library.
College Station: Texas A & M University Library.
Commerce: East Texas State College Library.
Corsicana: Navarro Junior College Library.
Dallas:
    Bishop College, Zale Library.

Dallas Public Library.
Southern Methodist University Library.
Denton: North Texas State University Library.
Edinburg: Pan American College Library.
El Paso:
El Paso Public Library.
University of Texas, Western College Library.
Fort Worth:
Fort Worth Public Library.
Texas Christian University Library.
Galveston: Rosenberg Library.
Houston:
Houston Public Library.
University of Houston Library.
Huntsville: Sam Houston State Teachers College, Estill Library.
Kingsville: Texas College of Arts and Industries Library.
Longview: Nicholson Memorial Library.
Lubbock: Texas Technological College Library—REGIONAL.
Marshall: Wiley College, Carnegie Library.
Nacogdoches: Stephen F. Austin State College Library.
Plainview: Wayland Baptist College, Van Howeling Memorial Library.
San Angelo: San Angelo College Library.
San Antonio:
Public Library, Business and Science Department.
St. Mary's University Library.
Trinity University Library.
San Marcos: Southwest Texas State College Library.
Sherman: Austin College, Arthur Hopkins Library.
Texarkana: Texarkana College Library.
Waco: Baylor University Library.
Wichita Falls: Midwestern University Library.

UTAH

Cedar City: College of Southern Utah Library.
Ephraim: Snow College Library.
Logan: Utah State University of Agriculture and Applied Science Library—REGIONAL.
Ogden: Weber College Library.
Provo: Brigham Young University Library.
Salt Lake City:
University of Utah Library.
Utah State Library.

VERMONT

Burlington: University of Vermont Library.
Johnson: Johnson Teachers College Library.
Middlebury: Middlebury College, Egbert Starr Library.
Montpelier: Vermont State Library.
Northfield: Norwich University Library.
Putney: Windham College, Dorothy Culbertson Marvin Library.

VIRGINIA

Blacksburg: Virginia Polytechnic Institute Library.
Bridgewater: Bridgewater College Library.
Charlottesville: University of Virginia Law Library.
Emory: Emory and Henry College Library.
Fairfax: George Mason College of the University of Virginia Library.
Fredericksburg: Mary Washington College Library.
Hampden Sidney: Hampden Sydney College Library.
Lexington:
Virginia Military Institute Library.
Washington and Lee University Library.
Norfolk:
Armed Forces Staff College Library.
Norfolk Public Library.
Old Dominion College, Hughes Library.
Petersburg: Virginia State College Library.
Richmond: Virginia State Library.
Roanoke: Roanoke Public Library.
Salem: Roanoke College, Bittle Memorial Library.
University: University of Virginia Library.
Univ. of Richmond, P.O.: University of Richmond Library.
Williamsburg: William and Mary College Library.

WASHINGTON

Bellingham: Western Washington State College Library.
Cheney: Eastern Washington State College Library.
Ellensburg: Central Washington State College Library.
Everett: Everett Public Library.
Olympia: Washington State Library—REGIONAL.
Port Angeles: Port Angeles Public Library.
Pullman: Washington State University Library.
Seattle:
Seattle Public Library.
University of Washington Library.
Spokane: Spokane Public Library.
Tacoma:
University of Puget Sound Library.
Tacoma Public Library.
Vancouver: Fort Vancouver Regional Library.
Walla Walla: Whitman College Library.

WEST VIRGINIA

Athens: Concord College Library.
Charleston:
Department of Archives and History, State Library.
Kanawha County Public Library.
Elkins: Davis and Elkins College Library.
Fairmont: Fairmont State College Library.
Glenville: Glenville State College Library.
Huntington: Marshall University Library.
Institute: West Virginia State College Library.
Morgantown: West Virginia University Library—REGIONAL.
Salem: Salem College Library.
Weirton: Mary H. Weir Public Library.

WISCONSIN

Appleton: Lawrence College Library.
Beloit: Beloit College Libraries.
Eau Claire: Wisconsin State College, William D. McIntyre Library.
Fond du Lac: Fond du Lac Public Library.
La Crosse:
Public Library.
Wisconsin State University Library.
Madison:
Madison Public Library.
State Historical Society Library—REGIONAL.*
University of Wisconsn Library.
Wisconsin State Library.
Milwaukee:
Milwaukee County Law Library—REGIONAL.
Mount Mary College Library.
Oklahoma Library.
University of Wisconsin—Milwaukee Library.
Oshkosh: Oshkosh State College Library.
Platteville: Wisconsin State College and Institute of Technology Karrmann Library.
Racine: Racine Public Library.
River Falls: Wisconsin State University, Chalmer Davee Library.
Stevens Point: Wisconsin State College Library.
Superior:
Superior Public Library.
Wisconsin State College, Curran Library.
Whitewater: Wisconsin State College, Harold Andersen Library.

WYOMING

Casper: Natrona County Public Library.
Cheyenne: Wyoming State Library.
Laramie: University of Wyoming Library.
Sheridan: Sheridan College, Mary Brown Kooi Library.

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* In cooperation with University of Wisconsin at Madison.

APPENDIX B. LIST OF FIELD OFFICES OF THE U.S. DEPARTMENT OF COMMERCE

ALBUQUERQUE, N. MEX. 87101
U.S. Courthouse
William E. Dwyer, Director
Area Code 505 Tel. 247-0311

ANCHORAGE, ALASKA 99501
306 Loussac-Sogn Building
Maurice H. Oaksmith, Director
Area Code 907 Tel. 272-6331

ATLANTA, GEORGIA 30303
4th Floor, Home Savings Building
75 Forsyth Street, N.W.
Daniel M. Paul, Director
Area Code 404 Tel. 526-6000

BALTIMORE, MARYLAND 21202
305 U.S. Customhouse
Gay and Lombard Streets
Carroll F. Hopkins, Director
Area Code 301-692-3560

BIRMINGHAM, ALA. 35205
Suite 200-201
908 South 20th Street
Gayle C. Shelton, Jr., Director
Area Code 205 Tel. 325-3327

BOSTON, MASS. 02203
Room 510, John F. Kennedy
Federal Building
Paul G. Carney, Director
Area Code 617 Tel. 223-2312

BUFFALO, N. Y. 14203
504 Federal Building
117 Ellicott Street
Robert F. Magee, Director
Area Code 716 Tel. 832-3208

CHARLESTON, S. C. 29403
Federal Building, Suite 631
334 Meeting Street
Paul Quattlebaum, Jr., Director
Area Code 803 Tel. 577-4171

CHARLESTON, W. VA. 25301
3002 New Federal Office Building
500 Quarrier Street
J. Raymond DePaulo, Director
Area Code 304 Tel. 343-6196

CHEYENNE, WYO. 82001
6022 Federal Building
2120 Capitol Avenue
Joseph D. Davis, Director
Area Code 307 Tel. 634-5920

CHICAGO, Ill. 60604
1486 New Federal Building
219 South Dearborn Street
Anthony J. Buchar, Director
Area Code 312 Tel. 353-4400

CINCINNATI, OHIO 45202
8028 Federal Office Building
550 Main Street
Thomas E. Ferguson, Director
Area Code 513 Tel. 684-2944

CLEVELAND, OHIO 44114
Room 600
666 Euclid Avenue
Charles B. Stebbins, Director
Area Code 216 Tel. 522-4750

DALLAS, TEX. 75202
Room, 1200, 1114 Commerce Street
Harry C. Meyers, Director
Area Code 214 Tel. 749-3287

DENVER, COLO. 80202
16419 Federal Building
20th and Stout Streets
Charles E. Brokaw, Director
Area Code 303 Tel. 297-3246

DES MOINES, IOWA 50309
609 Federal Building
210 Walnut Street
Raymond E. Eveland, Director
Area Code 515 Tel. 284-4222

DETROIT, MICHIGAN 48226
445 Federal Building
Frank A. Alter, Director
Area Code 313 Tel. 226-6088

GREENSBORO, N. C. 27402
258 Federal Building
West Market Street, P.O. Box 1950
Joel B. New, Director
Area Code 919 Tel. 275-9111

HARTFORD, CONN. 06103
18 Asylum Street
James E. Kelley, Director
Area Code 203 Tel. 244-3530

HONOLULU, HAWAII 96813
286 Alexander Young Building
1015 Bishop Street
H. Tucker Gratz, Director
Tel. 588-977

HOUSTON, TEX. 77002
5102 Federal Building
515 Rusk Avenue
Edward T. Fecteau, Jr., Director
Area Code 713 Tel. 228-0611

JACKSONVILLE, FLA. 32202
Post Office Box 35087
400 West Bay Street
Wm. Bruce Curry, Director
Area Code 904 Tel. 791-2796

KANSAS CITY, MO. 64106
Room 2011, 911 Walnut Street
Nathan L. Stein, Director
Area Code 816 Tel. 374-3141

LOS ANGELES, CALIF. 90015
Room 450, Western Pacific Bldg.
1031 South Broadway
Stanley K. Crook, Director
Area Code 213 Tel. 688-2833

MEMPHIS, TENN. 38103
Room 710
147 Jefferson Avenue
John M. Fowler, Director
Area Code 901 Tel. 534-3214

MIAMI, FLA. 33130
Room 821
City National Bank Building
25 West Flagler Street
Roger J. LaRoche, Director
Area Code 305 Tel. 350-5267

MILWAUKEE, WIS. 53203
Straus Building
238 West Wisconsin Avenue
David F. Howe, Director
Area Code 414 Tel. 272-8600

MINNEAPOLIS, MINN. 55401
306 Federal Building
110 South Fourth Street
Ernest G. Booth, Director
Area Code 612 Tel. 334-2133

NEW ORLEANS, LA. 70130
909 Federal Office Building, South
610 South Street
Edwin A. Leland, Jr., Director
Area Code 504 Tel. 527-6546

NEW YORK, N. Y. 10007
41st Floor, Federal Office Building
26 Federal Plaza, Foley Square
Arthur C. Rutzen, Director
Area Code 212 Tel. 264-0634

PHILDELPHIA, PENN. 19107
Jefferson Building
1015 Chestnut Street
David Jamieson, Director
Area Code 215 Tel. 597-2850

PHOENIX, ARIZ. 85025
5413 New Federal Building
230 North First Avenue
Donald W. Fry, Director
Area Code 602 Tel. 261-3285

PITTSBURGH, PENN. 15222
2201 Federal Building
1000 Liberty Avenue
Lewis E. Conman, Director
Area Code 412 Tel. 644-2850

PORTLAND, ORE. 97204
217 Old U.S. Courthouse
520 S. W. Morrison Street
James W. Goodsell, Director
Area Code 503 Tel. 226-3361

RENO, NEV. 89502
2028 Federal Building
300 Booth Street
Jack M. Howell, Director
Area Code 702 Tel. 784-5203

RICHMOND, VA. 23240
2105 Federal Building
400 North 8th Street
William S. Parker, Director
Area Code 703 Tel. 649-3611

ST. LOUIS, MO. 63103
2511 Federal Building
1520 Market Street
Alfred L. Rascher, Jr., Director
Area Code 314 Tel. 622-4243

SALT LAKE CITY, UTAH 84111
3235 Federal Building
125 South State Street
Stephen P. Smoot, Director
Area Code 801 Tel. 524-5116

SAN FRANCISCO, CALIF. 94102
Federal Building, Box 36013
450 Golden Gate Avenue
Philip M. Creighton, Director
Area Code 415 Tel. 556-5864

SAN JUAN, PUERTO RICO 00902
Room 100, Post Office Building
George R. Delgado
Trade Specialist in Charge
Phone: 723-4640

SAVANNAH, GA. 31402
235 U.S. Courthouse and
Post Office Building
125-29 Bull Street
James W. McIntire, Director
Area Code 912 Tel. 232-4321

SEATTLE, WASH. 98104
809 Federal Office Building
909 First Avenue
William H. Flood, Director
Area Code 206 Tel. 583-5615

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