A UNITED STATES
DEPARTMENT OF
COMMERCE
PUBLICATION

NBS SPECIAL PUBLICATION 305

SUPPLEMENT 2

Publications of the National Bureau of Standards 1970

U.S.
DEPARTMENT
OF
COMMERCE
National
Bureau
of
Standards

NATIONAL BUREAU OF STANDARDS

The National Bureau of Standards[1] was established by an act of Congress March 3, 1901. The Bureau's overall goal is to strengthen and advance the Nation's science and technology and facilitate their effective application for public benefit. To this end, the Bureau conducts research and provides: (1) a basis for the Nation's physical measurement system, (2) scientific and technological services for industry and government, (3) a technical basis for equity in trade, and (4) technical services to promote public safety. The Bureau consists of the Institute for Basic Standards, the Institute for Materials Research, the Institute for Applied Technology, the Center for Computer Sciences and Technology, and the Office for Information Programs.

THE INSTITUTE FOR BASIC STANDARDS provides the central basis within the United States of a complete and consistent system of physical measurement; coordinates that system with measurement systems of other nations; and furnishes essential services leading to accurate and uniform physical measurements throughout the Nation's scientific community, industry, and commerce. The Institute consists of a Center for Radiation Research, an Office of Measurement Services and the following divisions:

> Applied Mathematics—Electricity—Heat—Mechanics—Optical Physics—Linac Radiation[2]—Nuclear Radiation[2]—Applied Radiation[2]—Quantum Electronics[3]—Electromagnetics[3]—Time and Frequency[3]—Laboratory Astrophysics[3]—Cryogenics[3].

THE INSTITUTE FOR MATERIALS RESEARCH conducts materials research leading to improved methods of measurement, standards, and data on the properties of well-characterized materials needed by industry, commerce, educational institutions, and Government; provides advisory and research services to other Government agencies; and develops, produces, and distributes standard reference materials. The Institute consists of the Office of Standard Reference Materials and the following divisions:

> Analytical Chemistry—Polymers—Metallurgy—Inorganic Materials—Reactor Radiation—Physical Chemistry.

THE INSTITUTE FOR APPLIED TECHNOLOGY provides technical services to promote the use of available technology and to facilitate technological innovation in industry and Government; cooperates with public and private organizations leading to the development of technological standards (including mandatory safety standards), codes and methods of test; and provides technical advice and services to Government agencies upon request. The Institute also monitors NBS engineering standards activities and provides liaison between NBS and national and international engineering standards bodies. The Institute consists of the following technical divisions and offices:

> Engineering Standards Services—Weights and Measures—Flammable Fabrics—Invention and Innovation—Vehicle Systems Research—Product Evaluation Technology—Building Research—Electronic Technology—Technical Analysis—Measurement Engineering.

THE CENTER FOR COMPUTER SCIENCES AND TECHNOLOGY conducts research and provides technical services designed to aid Government agencies in improving cost effectiveness in the conduct of their programs through the selection, acquisition, and effective utilization of automatic data processing equipment; and serves as the principal focus within the executive branch for the development of Federal standards for automatic data processing equipment, techniques, and computer languages. The Center consists of the following offices and divisions:

> Information Processing Standards—Computer Information—Computer Services—Systems Development—Information Processing Technology.

THE OFFICE FOR INFORMATION PROGRAMS promotes optimum dissemination and accessibility of scientific information generated within NBS and other agencies of the Federal Government; promotes the development of the National Standard Reference Data System and a system of information analysis centers dealing with the broader aspects of the National Measurement System; provides appropriate services to ensure that the NBS staff has optimum accessibility to the scientific information of the world, and directs the public information activities of the Bureau. The Office consists of the following organizational units:

> Office of Standard Reference Data—Office of Technical Information and Publications—Library—Office of Public Information—Office of International Relations.

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[1] Headquarters and Laboratories at Gaithersburg, Maryland, unless otherwise noted; mailing address Washington, D.C. 20234.

[2] Part of the Center for Radiation Research.

[3] Located at Boulder, Colorado 80302.

UNITED STATES DEPARTMENT OF COMMERCE
MAURICE H. STANS, *Secretary*
NATIONAL BUREAU OF STANDARDS • Lewis M. Branscomb, *Director*

Publications of the National Bureau of Standards 1970

A Compilation of Abstracts and Key Word and Author Indexes

Betty L. Oberholtzer

U.S. National Bureau of Standards Special Publication 305 Supplement 2

To Accompany National Bureau of Standards Circular 460, its Supplement, Miscellaneous Publication 240, its Supplement, Special Publication 305 and its Supplement 1

Nat. Bur. Stand. (U.S.), Spec. Publ. 305 Suppl. 2, 378 pages (July 1971)
CODEN: XNBSA

Issued July 1971

For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402
(Order by SD Catalog No. C13.10:305 Suppl. 2)—Price $3.25

PREFACE

This publication continues the Bureau's practice of periodically making available a catalog of its most recent publications. Included are complete citations for all NBS papers published in the Bureau's own series and in outside media since the issuance of Supplement 1. Abstracts and key words are provided for each entry, organized by subject publication series, while author and key word indexes permit rapid location of specific papers by author or subject matter. An edge index on the back cover facilitates ready reference to the various NBS publication series, purchase procedures, and other areas of interest.

Appearing for the first time are citations of the first three publications of the new NBS Consumer Information Series. Also included are citations to the individual papers that comprise the proceedings of the "state-of-the-art" symposia held at the Bureau national and international areas of scientific and technological interest.

Like its two predecessors, this volume was prepared using the Bureau's computer-assisted photocomposition and publication system. The increasing number of NBS publications prepared in this manner represent significant progress in utilizing this aspect of computer technology. Of the many NBS personnel involved in this ongoing effort, special contributions have been made by Sharon Holdridge, Eula Lawson, Rebecca Morehouse and Robert Thompson. The NBS units involved are 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. As in previous years, approximately one-fourth of the NBS-authored papers cataloged here appeared in the Bureau's 10 nonperiodical and 4 periodical publications series. The remaining three-fourths appeared in non-Bureau media.

W. R. Tilley, Chief
Office of Technical Information
and Publications

Contents

1. NBS PERIODICAL AND NONPERIODICAL PUBLICATIONS

1.1. NBS PUBLICATION 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 1,000 items per year. These take the form of the Bureau's four periodicals, its ten 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 inhouse programs; these publications are as follows:

1.2. 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 chemical 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: 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

1.3. 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 services and publications. Issued monthly.

1.4. NONPERIODICALS

Ten 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.

SPECIAL PUBLICATIONS—provides material of a particular nature and quality. 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 had previously been designated Miscellaneous 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 world-wide 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.

FEDERAL INFORMATION PROCESSING STANDARDS PUBLICATIONS—publications in this series collectively constitute the Federal Information Processing Standards Register. The purpose of the Register is to serve as the official source of information in the Federal Government regarding (1) uniform Federal information processing standards resulting from provisions of Public Law 89-306 (the Brooks Bill), and (2) data elements and codes standards in data systems developed under the provisions of Bureau of the Budget Circular No. A-86. FIPS PUBS will include approved Federal information processing standards information of general interest, and a complete index of relevant standards publications.

CONSUMER INFORMATION SERIES—practical information, based on NBS research and experience, covering areas of interest to the consumer. Easily understandable language and illustrations provide useful background knowledge for shopping in today's technological marketplace.

1.5. 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.

2. PURCHASE PROCEDURES AND DOCUMENT AVAILABILITY

2.1. 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 for list of Field Offices of the U.S. Department of Commerce). Nonperiodicals (only) may also be ordered through the National Technical Information Service, U.S. Department of Commerce, Springfield, Virginia 22151.

This section includes 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 the 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.

Orders for publications purchased from the National Technical Information Service (NTIS) must be accompanied by postal money order, express money order, or check made out to the NTIS and covering total cost of the publications ordered. Information concerning NTIS coupons can be obtained directly from NTIS. All inquiries or orders should be addressed to: National Technical Information Service, Springfield, Virginia 22151.

2.2. 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 wholly 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.

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, $7.00; $8.75 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. Annual subscriptio, $2.50; $4.00 foreign.

2.3. CATALOGS OF NBS PUBLICATIONS

Previous catalogs, plus this publication, constitute a complete list of the titles of the Bureau's publications through December 31, 1970. 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 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. 223 pages, a citation of titles and abstracts, with key words and author indexes........	$2.00
Supplement 1 to Special Publication 305: Publications of the National Bureau of Standards, 1968 through 1969. 497 pages, a citation of titles and abstracts, with key words and author indexes......	$4.50
Supplement 2 to Special Publication 305: Publications of the National Bureau of Standards, 1970. 378 pages, a citation of titles and abstracts, with key words and author indexes...........................	$3.25

2.4. FUNCTIONS OF 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.

2.5. FUNCTIONS OF U.S. DEPARTMENT OF COMMERCE FIELD OFFICES

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.

2.6. AVAILABILITY OF NBS PUBLICATIONS

A. 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).....................	9.50	11.75
Bound volume (1 volume per year), blue buckram............	(3)	(3)
Section B. Mathematical Sciences, issued quarterly, paper covers (4)....................	5.00	6.25
Bound volume (1 volume per year), green buckram (4)......	(3)	(3)
Section C. Engineering and Instrumentation, issued quarterly, paper covers..............	5.00	6.25
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.

[1] United States and its possessions, Canada, Mexico, Newfoundland (including Labrador), 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).

B. PRICE LISTS FOR NONPERIODICALS

The following lists give the numbers and prices of all those NBS publications issued from 1901 through December 31, 1970 which are still in print. The prices shown herein supersede prices quoted in previous catalogs of NBS publications. Publications may be ordered from the Superintendent of Documents, U.S. Government Printing Office or from the U.S. Department of Commerce Field Office nearest you. Nonperiodicals (but not periodicals) may also be purchased from the National Technical Information Service. (See Section 2.1.)

When an item refers to "see—", the original item has been superseded by the item referenced, and the price shown is the sales price for the superseding publication. If "OP" is listed instead of a price, that publication is out of print. In such cases, your nearest depository library may still have a copy of the out-of-print item. (See Section 2.5 and Appendix A.)

CIRCULARS

No.	Price
3 see C547, Sec. 1, in part	OP
8 see Mono. 90	$0.25
9 see C602	OP
10 see C425	OP
12 see C440	OP
16 see C555	OP
17 see Mono. 47	.30
25 see M260	.45
29 see C60	OP
31 see H100	.50
32 see C405	OP
35 see M183	OP
40 see C381	OP
44 see C440	OP
47 see M233	OP
49 see H8	OP
51 see C432	OP
52 see C387	OP
54 see H3 & H4	OP
57 see C410	*
61 see H29	OP
62 see C424	OP
65 see C417	OP
75 see C397	OP
76 see C346	OP
82 see C361	OP
83 see C333	OP
95 see C426	OP
100 see C592	OP
101 see C447	OP
131 see C385	OP
138 see C385	OP
139 see C390	OP
154 see H71	*
239 see C363	OP
257 see C365	OP
280 see C406	OP
294 see C407	OP
300 see C418	OP
319 see C378	OP
322 see C360	OP
328 see Mono. 15	OP
330 see C362	OP
332 see Mono. 15	OP
339 see C363	OP
371 see C378	OP
375 see C457	OP
380 see C418	OP
383 see C424	OP
390 see H71	*
392 see C432	OP
396 see C418	OP
398 see M260	$0.45
399 see C406	OP
400 see C426	OP
402	.05
410	*
413 see C426	OP
414 see H71	*
415 see Mono. 47	.30
428 see C533	2.50
434 see C602	OP
435 see H71	*
438	*
450 see C579	*
454 (PB192338)	**
456 see Mono. 47	.30
460	1.25
460 Suppl	1.50
462 see Mono. 80, in part	2.75
464	*
465 see H90	.40
466 see H71	*
470	.30
474 see C576	*
477 see C555	OP
478 see Mono. 104	.35
482 see C509	OP
485 see C592	OP
488 Sect. 1 & 2	1.25
488 Sect. 3, 4, & 5	1.50
495 see Mono. 88	.35
499	*
500 Pt. I see TN270-3	$1.25
500 Pt. II see TN270-3	1.25
506 see C576	*
508 see C561	OP
510 (PB192339)	***
510 Suppl. 1 (PB192340)	**
510 Suppl. 2 (PB192341)	**
518 See Mono. 70,	
Vol. I in part	2.00
Vol. II in part	3.00
533	2.50
536	.20
537 see NSRDS-NBS 10	.40
539 Vol. 1 to 10 are now PB178902 through PB178911	**
542 (PB188806)	**
552 see M260	.45
553	2.00
556 (PB172004)	**
559 see H71	*
563 & 563 Suppl. 1, see M274	.50
564	*
567 see M271	1.25
571 (PB175659)	**
572 see Mono. 15	OP
576	*
577 & 577 Suppl	*
579 (PB168350)	*
580 see M251	OP
582	3.25
589 (PB188296)	**
592 see Mono. 106	1.25
593	.45
596 (PB172059)	**
600 see Mono. 90	.25
601	.30

*See page 17 for additional information.

**Now available from the National Technical Information Service, order by PB number.

***Now available from the National Technical Information Service, ordered by PB number.

MONOGRAPHS

No.	Price
2 (PB187752)	*
3 Vol. I	$6.00
3 Vol. II	6.00
4 (PB174987)	*
8 (PB186237)	*
10	.20
11	.20
12	1.50
13 (PB172156)	*
14	.15
17	.65
18 see Mono. 88	.35
20	2.75
22	2.00
23 (PB183992)	*
24	.20
25 Sect. 1 (PB178429)	*
25 Sect. 2 (PB178430)	*
25 Sect. 3 (PB178431)	*
25 Sect. 4	.55
25 Sect. 5	.55
25 Sect. 6	.60
25 Sect. 7	1.50
25 Sect. 8	1.50
26	.20
27 Suppl. incl. in Suppl. 2	.35
27 Suppl. 2	.35
28 see BSS17	.40
29 (PB172178)	*
30 (PB193908)	*
31	.35
32 Suppl. to Parts I & II	.30
33	.55
34 Vol. 2	2.00
35	.60
35 Suppl. 1	.65
36	.30
38	.70
40	$0.50
41 (PB191728)	*
42	.75
43 Vol. I	6.50
43 Vol. II	6.25
44	.15
45 (PB186433)	*
46 (PB176590)	*
47	.30
49	2.75
50 see M278	.55
& M278 Suppl	.30
51	.30
52	1.00
54	.25
55	.20
56	.30
57 see M274	.50
58 (PB193909)	*
59	1.75
60	.25
61	4.00
62	.15
63	.35
64	.15
65	.15
66	.35
67 (PB186426)	*
68	.25
69	.30
70 Vol. I (PB168072)	*
70 Vol. II (PB189714)	*
70 Vol. III	4.25
70 Vol. IV	5.50
70 Vol. V	4.75
71	2.00
72 (PB186427)	*
73 (PB186432)	*
74	.30
75	.40
76	$0.20
77* (PB180646)	**
78	.20
79	.35
80	2.75
81	3.25
82 (PB189659)	**
83	.55
85	.70
86	.35
87	.40
88	.35
89 (AD700466)	**
90	.25
91	2.25
92	2.75
93	.75
94	.75
95	.45
96	1.25
97	.25
98	.55
99	.70
100	4.50
101	2.75
102	.25
103	.20
104	.35
105	2.25
106	1.25
107	1.75
108	.45
109	.55
110	.30
111	2.00
112	.35
113 Vol. I	1.50
113 Vol. II	1.25
113 Vol. III	1.25
114	.60
115	.55
116	1.50
117	.35
118	.50

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*Consolidated supplement to BMS144 and supersedes supplements 1 & 2 of BMS144.
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APPLIED MATHEMATICS SERIES

No.	Price	No.	Price	No.	Price
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2 (PB194385)	*	28 (AD695952)	*	51	$4.50
5	.50	29 (AD695953)	*	53 (PB186430)	*
6	2.25	30 (PB175817)	*	54	.30
8	.30	31	4.75	55	6.50
9	1.75	32	2.25	56 (PB190608)	*
10	2.00	33 (PB175818)	*	57	.35
11	.70	34	2.00	58	.40
12 (PB184887)	*	35	2.00	59	3.25
13	.40	36	4.00	60	.60
14	5.50	40 (PB186428)	*	61	.70
17	2.00	41 (PB176521)	*		
19 (PB175815)	*	42 (PB175819)	*		
20	1.75	43 (PB176127)	*		
21 (PB178392)	*	44 (AD695954)	*		
22 (PB192337)	*	45	.55		
23 (PB175967)	*	46 (PB186429)	*		
24 (PB175816)	*	47	.45		
25	.45	48 (PB176119)	*		
26 (PB178415)	*	49	.50		

*Now available at the National Technical Information Service, order by PB or AD number.

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17 see BMS144	OP	19 see BMS116	OP	144 & Suppl. 1 & 2, see Mono. 77 (PB180647)	*
17 Suppl. 1 & 2, see Mono. 77 (PB180647)	*	64 (PB177986)	*	151 (PB177987)	*
		66	$0.60		
		140 Third Ed	.30		

*Now available at the National Technical Information Service, order by PB number.

MISCELLANEOUS PUBLICATIONS

No.	Price	No.	Price	No.	Price
3 see M232	$0.50	174 see M211	$0.20	262–2	$4.25
39 see M234	.10	179	*	265	3.00
54 see BH5	OP	187	*	266	3.75
64 see M247	.40	203 see M243	OP	267	2.00
65 see M178	OP	211	.20	268 (6.25 for 100)	.10
78 see M82	OP	214 see M286	2.25	269	2.75
85 see H29	OP	230 see M288	2.00	271	1.25
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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. Microfische of this Circular is available from Cryogenic Data Center, National Bureau of Standards, Boulder, Colorado 80302 for $4.50.

Circular 576, Automotive Antifreezes. For information on this subject consult American National Standards Institute, 1430 Broadway, New York, N.Y. 10018.

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.

Miscellaneous Publication 179, American Standard Building Code Requirements for Minimum Design Loads in Buildings and Other Structures. The American National Standards Institute, 1430 Broadway, New York, N.Y. 10018, 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 (C5.1-1969) is available from the American National Standards Institute, 1430 Broadway, New York, N.Y. 10018, at $1.25.

Handbook 49, Recommendations for Waste Disposal of Phosphorus-32 and Iodine-131 for Medical Users. Reprints of this Handbook can be purchased as NCRP Report 9 at $1.00 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 as NCRP Report 16 at $1.00 from ICRU Publications, Post Office Box 4867, Washington, D.C. 20008.

Handbook 59, Permissible Dose from External Sources of Ionizing Radiations. Reprints of this Handbook can be purchased as NCRP Report 39 at $2.00 per copy from NCRP Publications, Post Office Box 4867, Washington, D.C. 20008.

Handbook 63, Protection Against Neutron Radiation up to 30 MeV. Reprints of this Handbook can be purchased as NCRP Report 20 at $1.00 per copy from NCRP Publications, Post Office Box 4867, Washington, D.C. 20008.

Handbook 65, Safe Handling of Bodies Containing Radioactive Isotopes. Reprints of this Handbook can be purchased as NCRP Report 21 at $1.00 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 American National Standards Institute, 1430 Broadway, New York, N.Y. 10018.

Handbook 74, Building Code Requirements for Reinforced Masonry. The American National Standards Institute, 1430 Broadway, New York, N.Y. 10018 has issued a publication on this subject. Available from them as A41.2–1960 (R1970), at $2.75.

Handbook 76, Medical X-ray Protection Up to Three Million Volts. For more information on this Handbook, write to NCRP Publications, Post Office Box 4867, Washington, D.C. 20008.

Handbook 84, Radiation Quantities and Units, has been superseded by ICRU Report 11 at $1.00 per copy from ICRU Publications, Post Office Box 4869, Washington, D.C. 20008.

Handbook 89, Methods of Evaluating Radiological Equipment and Materials. Reprints of this Handbook can be purchased as NCRP Report 10F at $1.25 per copy from ICRU Publications, Post Office Box 4869, Washington, D.C. 20008.

Handbook 97, Shielding for High-Energy Electron Accelerator Installations. Reprints of this Handbook can be purchased as NCRP Report 31 at $1.00 per copy from NCRP Publications, Post Office Box 4867, Washington, D.C. 20008.

Handbook 102, ASTM Metric Practice Guide. American Society for Testing and Materials, 1916 Race Street, Philadelphia, Pa. 19103, has issued a publication as Document E380–70, at $1.50.

3. TITLES AND ABSTRACTS OF NBS PUBLICATIONS, 1970 [1]

3.1. PAPERS FROM THE JOURNAL OF RESEARCH OF THE NATIONAL BUREAU OF STANDARDS, SECTION A. PHYSICS AND CHEMISTRY, VOLUME 74A, JANUARY-DECEMBER 1970

January-February 1970

Standardization of cesium-137 gamma-ray sources in terms of exposure units (roentgens), T. P. Loftus, *J. Res. Nat. Bur. Stand. (U.S.),* **74A** (Phys. and Chem.), No. 1, 1-6 (Jan.-Feb. 1970).

Key words: Calibration; cavity ionization chamber; cesium-137; exposure rate; scattered radiation; standardization.

^{137}Cs γ-ray sources, which have been proposed by the Public Health Service as a substitute for radium in the treatment of malignant diseases, require suitable calibration if consistency is to be achieved in radiation treatment.

Several ^{137}Cs sources were calibrated using a graphite cavity ionization chamber in an open-air geometry. The contribution of scatter from the room surfaces was calculated and the source measurements corrected for this effect.

A large-volume aluminum-walled ionization chamber was designed and fabricated for use in routine calibrations. This chamber will be used as a means for intercomparison of the source to be calibrated with one of the standards.

Calculations of Zn II 3d⁹4s5s and Ag I 4d⁹5s6s, and some new levels in these spectra, W. C. Martin and J. Sugar, *J. Res. Nat. Bur. Stand. (U.S.),* **74A** (Phys. and Chem.), No. 1, 7-10 (Jan.-Feb. 1970).

Key words: Atomic spectra; energy levels; silver; zinc.

Results of intermediate-coupling calculations are given for Zn II $3d^94s5s$ and Ag I $4d^95s6s$. A $[(4d^9)J_I, (5s6s)J_{II}]J$ coupling scheme is appropriate for the latter. New $3d^94s(^3\mathrm{D})5s\ ^2\mathrm{D}_{21/2}$ and $3d^94s(^1\mathrm{D})5s\ ^2\mathrm{D}_{21/2}$ levels were found in Zn II, and a few other additions and revisions are given for the analysis. The combinations of the new levels $3d^9(^2\mathrm{D})4s4p(^3\mathrm{P}^\circ)\ ^4\mathrm{F}^\circ_{41/2}$ in Zn II and $4d^9(^2\mathrm{D})5s5p(^3\mathrm{P}^\circ)\ ^2\mathrm{F}^\circ_{21/2}$ in Ag I are also listed.

New vacuum ultraviolet wavelengths and revised energy levels in the second spectrum of zinc (Zn II), W. C. Martin and V. Kaufman, *J. Res. Nat. Bur. Stand. (U.S.),* **74A** (Phys. and Chem.), No. 1, 11-22 (Jan.-Feb. 1970).

Key words: Atomic energy levels of Zn II; ionized zinc; spectral wavelengths of Zn II.

Spectra from sliding spark discharges between zinc electrodes and from a hollow-cathode source were photographed in the range 2105-1400 Å with the NBS 10.7 m vacuum spectrograph. New measurements of 130 Zn II lines in this region, combined in some cases with previous measurements in the air region, were used to derive revised positions for the known levels. Wavelengths calculated from these levels are given for 267 lines in the region 2570-730 Å. The line list also includes unclassified Zn II lines below 2570 Å, based on the most complete description of this spectrum [A. M. Crooker and K. A. Dick, Can. J. Phys. **46,** 1241 (1968)]. A few additions to the line list of Crooker and Dick above 2700 Å are given. The line and level lists take into account recent work at the National Bureau of Standards on the Zn II analysis.

CIE 1960 UCS diagram and the Müller theory of color vision, D. B. Judd and G. T. Yonemura, *J. Res. Nat. Bur. Stand. (U.S.),* **74A** (Phys. and Chem.), No. 1, 23-30 (Jan.-Feb. 1970).

Key words: Chromaticity; color; perception; protanopia; tritanopia; vision.

A close relationship has been shown to exist between the second stage of the Müller theory and the MacAdam 1937 (u, ϵ)-diagram recommended in 1960 by the CIE for interim use as a chromaticity diagram having approximately uniform scales. By considering normal vision as a combination of protanopia and tritanopia as suggested by the Müller second stage, a more general measure of the perceived size of a chromaticity difference is developed than the length of the line connecting the two chromaticity points. The general measure is the square root of the sum of the squares of the angles subtended by the line at the convergence points of the chromaticity confusion lines for protanopia and tritanopia, respectively. By this measure the chromatic sensibility to wavelength change in the spectrum is accounted for quantitatively not only for protanopic and tritanopic vision, but also for normal vision including the secondary maximum of sensibility in the neighborhood of 420 nm.

Blemish formation in processed microfilm II, C. I. Pope, *J. Res. Nat. Bur. Stand. (U.S.),* **74A** (Phys. and Chem.), No. 1, 31-36 (Jan.-Feb. 1970).

Key words: Archival record film; microfilm; microfilm storage cartons; permanent record film; peroxides; redox blemishes; zinc powder.

Gaseous peroxides form blemishes on some processed microfilms. Two procedures are given for testing the blemish susceptibility of processed microfilm, one using peroxide paper and the other zinc powder as a source of peroxide. The susceptibility of microfilm to blemish formation decreased when conditioned at 86 percent relative humidity and 26 °C. Coarse-grain microfilms are less susceptible to blemish formation than fine-grain microfilm. Fine-grain microfilms fixed in ammonium thiosulfate were less susceptible to blemish formation than those fixed in sodium thiosulfate. Oven-aged microfilm storage cartons were found to generate peroxide when wetted. The microfilm base readily absorbed hydrogen peroxide.

Positive and negative ion sublimation from transition metal surfaces: A review of some recent results, M. D. Scheer, *J. Res. Nat. Bur. Stand. (U.S.),* **74A** (Phys. and Chem.), No. 1, 37-43 (Jan.-Feb. 1970).

Key words: Mass spectrometry; positive and negative ions; sublimation; transition metals.

Singly charged, positive and negative, atomic ions have been observed to sublime freely from $4d$ and $5d$ transition metal surfaces in the 1800 to 2600 K temperature range. The rates of

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[1] The various NBS publications series are grouped under subheadings within this section. The several volumes of the Journal of Research are presented consecutively within their appropriate subheadings. If a particular publications series is sought, consult the table of contents or the edge index on the back cover.

sublimation were found to be about equal to those which would be observed under conditions of thermal equilibrium. Ion sublimation energies were obtained from the temperature dependence of these sublimation rates. The energies were found to be consistent with currently accepted values for the atom sublimation energy, electron work function, and first ionization potentials of the elements investigated.

The electron affinities of these metal atoms were determined from an isothermal measurement of the ratio of positive to negative ion sublimation rates. The results were compared with some recent theoretical estimates of this quantity for those 3*d* transition metals whose valence electron configurations are analogous to the 4*d* and 5*d* elements considered here.

Generation of controlled low pressures of nitrogen by means of dissociation equilibria, R. H. Orcutt, *J. Res. Nat. Bur. Stand. (U.S.),* **74A** (Phys. and Chem.), No. 1, 45-49 (Jan.-Feb. 1970).

> Key words: Barium nitride; dissociation equilibria; nitrides; nitrogen; thermodynamic properties; vacuum; vacuum measurement.

It is shown that fixed low pressures of nitrogen in the vacuum region can be generated by chemical dissociation in a system at equilibrium at constant temperature. Dissociation pressures ranging from 2×10^{-5} to 0.7 torr (3×10^{-3} to 90 $N \cdot m^{-2}$), corresponding to temperatures of 740 to 1150 K, for the reaction

$$Ba_3N_2 \rightleftarrows 3/2\ Ba_2N + 1/4\ N_2$$

have been measured. The pressures, *p*, in $N \cdot m^{-2}$ are represented by the equation

$$\ln p = (22.02 \pm 0.14) - (20{,}080 \pm 140)/T,$$

where *T* is the absolute temperature, and the uncertainties are least squares estimates of the standard deviations of the parameters.

Temperature coefficient of the bismuth I-II transition pressure, J. C. Houck, *J. Res. Nat. Bur. Stand. (U.S.),* **74A** (Phys. and Chem.), No. 1, 51-63 (Jan.-Feb. 1970).

> Key words: Bismuth transition; calibration point; high pressure; pressure measurement; temperature coefficient.

A rotatable piston in a supported cylinder was used to determine the temperature coefficient of the bismuth I-II transition pressure for the temperature range of 20 to 50 °C. The temperature coefficient of the transition pressure is −40.6 bar/°C.

Isothermal diffusion in the dilute range of the system $Ca(OH)_2 - H_3PO_4 - H_2O$: Theory, E. C. Moreno, P. R. Patel, and W. E. Brown, *J. Res. Nat. Bur. Stand. (U.S.),* **74A** (Phys. and Chem.), No. 1, 55-63 (Jan.-Feb. 1970).

> Key words: Diffusion; phenomenological coefficients; polycomponent systems; reciprocal relations.

The equations describing isothermal diffusion in the dilute range of the ternary system $Ca(OH)_2 - H_3PO_4 - H_2O$ are derived in two ways, first, assuming that the components are electroneutral species and, second, considering the actual ionic species present in solution. It is shown that the two models are thermodynamically equivalent. The theory permits the calculation of the four fundamental diffusion coefficients (phenomenological coefficients) in the concentration range where the Debye-Hückel theory suffices for the calculation of ionic activity coefficients. The equations can be used to test the Onsager reciprocal relations for the diffusion process in the above system. The ionic model was used to calculate practical diffusion coefficients for the electroneutral components from the limiting equivalent conductances of the ions in solutions saturated with respect to hydroxyapatite, $Ca_{10}(OH)_2(PO_4)_6$. Large diffusion interferences, as revealed by relatively large values for the cross-terms in D_{ij}, are predicted even for solutions with total molarity in the order of 10^{-5}. Therefore, diffusion models based on independent fluxes of the components appear to be invalid.

High-speed (subsecond) measurement of heat capacity, electrical resistivity, and thermal radiation properties of molybdenum in the range 1900 to 2800 K, A. Cezairliyan, M. S. Morse, H. A. Berman, and C. W. Beckett, *J. Res. Nat. Bur. Stand. (U.S.),* **74A** (Phys. and Chem.), No. 1, 65-92 (Jan.-Feb. 1970).

> Key words: Electrical resistivity; emittance; heat capacity; high-speed measurements; high temperature; molybdenum; thermal radiation properties; thermodynamics.

A technique is described for the high-speed measurement of heat capacity, electrical resistivity, hemispherical total and normal spectral emittances of electrical conductors at high temperatures (above 1900 K) with millisecond resolution. Duration of an individual experiment, in which the specimen is heated from room temperature to close to its melting point, is less than one second. Temperature measurements are made with a high-speed photoelectric pyrometer. Quantities are recorded by a high-speed digital data acquisition system which has a resolution of approximately one part in 8000. Time resolution of the entire system is 0.4 ms. Results on the above properties of molybdenum in the temperature range 1900 to 2800 K are reported and are compared with those in the literature. Estimated inaccuracy of measured properties in the above temperature range is: 2 to 3 percent for heat capacity, 0.5 percent for electrical resistivity, 3 percent for hemispherical total emittance and 2 percent for normal spectral emittance.

P−V−T, thermodynamic and related properties of oxygen from the triple point to 300 K at pressures to 33 MN/m², L. A. Weber, *J. Res. Nat. Bur. Stand. (U.S.),* **74A** (Phys. and Chem.), No. 1, 93-129 (Jan.-Feb. 1970).

> Key words: Density; enthalpy; entropy; equation of state; fixed points (PVT); Joule-Thomson; latent heat; melting curve; oxygen; properties of fluids; saturated liquid and vapor; specific heat; vapor pressure; velocity of sound.

The results of new experimental pressure-volume-temperature measurements on oxygen are presented. The data range in temperature from 54 to 300 K and in pressure from 0.1 to about 33 MN/m². The following properties are tabulated for selected isobars: molar volume, $(\partial P/\partial \rho)_T$, $(\partial P/\partial T)_\rho$, internal energy, enthalpy, entropy, specific heats at constant volume and at constant pressure, and the velocity of sound. Additional tables present the above properties for saturated liquid and vapor, the freezing liquid P−V−T relationship, and the derived Joule-Thomson inversion curve. New values for the critical density and triple point density are presented, and the second and third virial coefficients are tabulated.

March-April 1970

A theoretical investigation of the configurations $(3d+4s)^4 4p$ in neutral vanadium (V I), C. Roth, *J. Res. Nat. Bur. Stand. (U.S.),* **74A** (Phys. and Chem.), No. 2, 141-156 (Mar.-Apr. 1970).

> Key words: Configurations in V I; configurations $(3d+4s)^4 4p$ in V I; configuration interaction; energy levels of V I; first spectrum; *g*-values V I; parameters; theory; vanadium; V I; Zeeman effect.

Experimental levels of the configurations $(3d+4s)^4 4p$ in V I were compared with corresponding calculated values. On fitting 228 experimental levels by means of 20 free parameters an rms error in the calculated values of 216 cm⁻¹ was obtained. All the 438 theoretically predicted levels and *g*-factors were calculated.

A theoretical investigation of the configurations $(3d+4s)^54p$ in neutral chromium (Cr I), C. Roth, *J. Res. Nat. Bur. Stand. (U.S.),* **74A** (Phys. and Chem.), No. 2, 157-179 (Mar.-Apr. 1970).

Key words: Chromium; configurations in Cr I; configurations $(3d+4s)^54p$ in Cr I; configuration interaction; Cr I; energy levels of Cr I; first spectrum; *g*-values Cr I; parameters; theory; Zeeman effect.

Experimental levels of the configurations $(3d+4s)^54p$ in Cr I were compared with corresponding calculated values. On fitting 296 experimental levels by means of 20 free parameters an rms error of 183 cm^{-1} was obtained. All the 684 theoretically predicted levels and *g*-factors are calculated.

It is shown that the correction parameters β and T are not significant here.

A theoretical investigation of the configurations $(3d+4s)^74p$ in neutral iron, C. Roth, *J. Res. Nat. Bur. Stand. (U.S.),* **74A** (Phys. and Chem.), No. 2, 181-202 (Mar.-Apr. 1970).

Key words: Arc spectrum; configurations $(3d+4s)^74p$; configuration interactions; energy levels; *g*-factors; iron.

Experimental levels of the configurations $(3d+4s)^74p$ were compared with corresponding calculated values. On fitting 248 experimental levels by means of 20 free parameters an rms error of 213 cm^{-1} was obtained.

It was shown that the correction parameters β and T were not significant.

The intensity as a function of temperature of the low-angle x-ray diffraction maxima of the *n*-paraffins: Hexatriacontane, tetratetracontane, and tetranonacontane, P. K. Sullivan and J. J. Weeks, *J. Res. Nat. Bur. Stand. (U.S.),* **74A** (Phys. and Chem.), No. 2, 203-214 (Mar.-Apr. 1970).

Key words: Defects; *n*-paraffins; phase transition; temperature dependence; x-ray diffraction.

The diffraction of x-rays by the crystalline *n*-paraffins, $C_{36}H_{74}$, $C_{44}H_{90}$, and $C_{94}H_{190}$, was examined at small angles—below seven degrees 2θ—as a function of temperature. The Bragg maxima $(00l)$ that occur at these angles result from a lamellar repeat distance which depends on the molecular length. In general the intensity of these maxima was found to increase with increasing temperature in an approximately reversible manner. All the samples experienced solid-solid phase transitions in the temperature range of observation. Several possible mechanisms consistent with the temperature dependence of the intensity are considered.

Photoelastic constants of ruby, R. M. Waxler and E. N. Farabaugh, *J. Res. Nat. Bur. Stand. (U.S.),* **74A** (Phys. and Chem.), No. 2, 215-220 (Mar.-Apr. 1970).

Key words: Birefringence; crystals, lasers; photoelasticity; ruby.

The eight piezo-optic and eight elasto-optic constants of synthetic, single crystal ruby have been determined using the cadmium red radiation of 643.8 nanometers (nm). All the constants are found to be negative in value, or to have very small positive values. The data indicate that changes in the polarizability of the oxygen ion and changes in the local field are primarily responsible for the observed changes in refractive index. Hydrostatic pressure has been used for the first time as part of a complete photoelastic investigation, and a new, screw-clamp device for easily attaining high, uniaxial stress is described.

Estimation of critical constants T_c, ρ_c from the $\rho(T)$ and $T(\rho)$ relations at coexistence, R. D. Goodwin, *J. Res. Nat. Bur. Stand. (U.S.),* **74A** (Phys. and Chem.), No. 2, 221-227 (Mar.-Apr. 1970).

Key words: Coexistence; coexistence temperatures; critical constants; critical density; critical temperatures; fluorine; neon; oxygen; orthobaric densities; parahydrogen; saturated liquid and vapor densities.

The critical temperature T_c and the critical density ρ_c are estimated from new equations (1) for the double-valued $\rho(T)$ relation, and (2) for the single-valued $T(\rho)$ relation. For method (1) this report gives concise descriptions of the rectilinear diameter and of the densities of liquid oxygen. Calculated vapor densities agree well with experimental oxygen data over the wide range from triple- to critical-point. Method (2) is applied to hydrogen, oxygen, fluorine, and neon, giving the $T(\rho)$ relation and estimates for T_c and ρ_c all in one step from the complete set of liquid and vapor data.

Synthesis and growth of fresnoite ($Ba_2TiSi_2O_8$) from a TiO_2 flux and its relation to the system $BaTiO_3$-SiO_2, C. R. Robbins, *J. Res. Nat. Bur. Stand. (U.S.),* **74A** (Phys. and Chem.), No. 2, 229-232 (Mar.-Apr. 1970).

Key words: $Ba_2TiSi_2O_8$; $BaTiSiO_5$; crystal growth; fresnoite; phosphor; piezoelectric; system $BaTiO_3$-SiO_2; TiO_2 solvent.

Crystals of $Ba_2TiSi_2O_8$ (synthetic fresnoite) up to 5 mm in longest dimension have been grown by slow cooling of a TiO_2-rich liquid of initial composition $1BaO$:$1TiO_2$:$1SiO_2$. The synthetic crystals are essentially identical to their mineral equivalent in morphology, cleavage, optical properties and unit cell dimensions. X-ray powder diffraction data previously reported for the compound $BaTiSiO_5$ ("barium sphene") is that of $Ba_2TiSi_2O_8$. Apparently the compound $BaTiSiO_5$ has never been synthesized and the system $BaTiO_3$-SiO_2 is not binary.

Photoionization study of $Fe(CO)_5$ and $Ni(CO)_4$, G. Distefano, *J. Res. Nat. Bur. Stand. (U.S.),* **74A** (Phys. and Chem.), No. 2, 233-238 (Mar.-Apr. 1970).

Key words: Dissociation energies; $Fe(CO)_5$; heats of formation; ionization; mass spectrometry; $Ni(CO)_4$; vacuum ultraviolet spectroscopy.

Photoionization yield curves from onset to 600 Å, and ionization threshold values have been obtained for the ions $Fe(CO)_5^+$, $Fe(CO)_4^+$, $Fe(CO)_3^+$, $Fe(CO)_2^+$, $Fe(CO)^+$, Fe^+ and CO^+ from iron pentacarbonyl, and for $Ni(CO)_4^+$, $Ni(CO)_3^+$, $Ni(CO)_2^+$, $Ni(CO)^+$, Ni^+, and CO^+ from nickel tetracarbonyl. From these curves, information on the ionization-fragmentation processes of $Fe(CO)_5$ and $Ni(CO)_4$ under photon impact, have been obtained. Differences in the threshold energies as determined by photon and by electron impact methods increase with the fragmentation. The appearance potentials and the heats of formation of the metal-ions, agree within 0.1 eV, with those calculated from thermochemical data. The average bond dissociation energy of the neutral molecule agrees within 0.02 eV, with the thermochemical values. The kinetic shift for the formation of Fe^+ and Ni^+ ions is very small. The Ni^+ ion is most likely formed directly from the molecule ion rather than by a cascade fragmentation process.

The band structure problem, J. M. Ziman, *J. Res. Nat. Bur. Stand. (U.S.),* **74A** (Phys. and Chem.), No. 2, 241-252 (Mar.-Apr. 1970).

Key words: APW; band structure; density of states; disordered systems; KKR; pseudopotential; t-matrix; molecular crystals.

The numerical solution of the Schrödinger equation for an electron in a dense assembly of atoms (i.e., a solid or liquid metal or semiconductor) has made great progress in the past ten years. This is not merely a consequence of greater computer power; we now have a much better grasp of the mathematical theory of such solutions.

By 1960 a number of practical methods had been devised for the computation of the electronic structure of ordered crystals, but these lacked intuitive interpretation. The first advance was to rewrite the OPW method in terms of pseudopotentials, thus making sense of the free-electron theory of metals. This development has proved particularly valuable in semiquantitative and empirical investigations of Fermi surfaces, transport properties, lattice dynamics, cohesion, etc., but we have had to wait until recently for a rigorous analysis of the criteria for convergence of the various types of model potential or pseudopotential that have been postulated.

The next step was to show that the KKR (Green function) method could also be expressed as a pseudopotential, and then to demonstrate that this was also a form of APW expansion. The relative computational power of these two methods can thus be analyzed, and questions answered concerning the fulfillment of the empty lattice test, the apparent lack of uniqueness of the expansions, the advantages of "folding" matrix elements from distant points of the reciprocal lattice, and the introduction of contributions from the interstitial potential.

At this stage, the connections between the band structure problem and the t-matrix theory of scattering were uncovered, and d-bands were seen to arise as resonances of the muffin-tin wells. The KKR matrix could now be rewritten as a mixture of pseudopotential and tight-binding elements, in harmony with the empirical model Hamiltonian representations of hybridized s-p and d-bands. This method not only permits more rapid computations, but shows clearly how the width and position of such bands should depend on the atomic potential.

Some problems still remain. For example, present techniques do not seem adequate for first-principles calculations on molecular crystals, where the anisotropy of the interstitial potential (i.e., easy channels along bonds, but high hills between layers or chains) is probably the dominant feature.

As for disordered systems—we know little for certain and nothing quantitatively. The linear chain model has been fully studied but is quite irrelevant to the three-dimensional case. The present theoretical confusion is exemplified by the equiconcentration substitutional alloy in the tight-binding limit; some formulae give only one band, others allow two. Again, the very possibility of producing band gaps by diffraction of free electrons in a topologically disordered system (e.g., amorphous Ge) has not been demonstrated mathematically with any rigor.

Optical properties and electronic density of states, M. Cardona, *J. Res. Nat. Bur. Stand. (U.S)*, **74A** (Phys. and Chem.), No. 2, 253-265 (Mar.-Apr. 1970).

Key words: Critical points; density of states; dielectric constant; modulated reflectance; optical absorption.

The fundamental absorption spectrum of a solid yields information about critical points in the optical density of states. This information can be used to adjust parameters of the band structure. Once the adjusted band structure is known, the optical properties and the density of states can be generated by numerical integration. We review in this paper the parametrization techniques used for obtaining band structures suitable for density of states calculations. The calculated optical constants are compared with experimental results. The energy derivative of these optical constants is discussed in connection with results of modulated reflectance measurements. It is also shown that information about density of empty states can be obtained from optical experiments involving excitation from deep core levels to the conduction band.

A detailed comparison of the calculated one-electron optical line shapes with experiment reveals deviations which can be interpreted as exciton effects. The accumulating experimental evidence pointing in this direction is reviewed together with the existing theory of these effects.

A number of simple models for the complicated interband density of states of an insulator have been proposed. We review in particular the Penn model, which can be used to account for response functions at zero frequency, and the parabolic model, which can be used to account for the dispersion of response functions in the immediate vicinity of the fundamental absorption edge.

Excitonic effects in x-ray transitions in metals, G. D. Mahan, *J. Res. Nat. Bur. Stand. (U.S.)*, **74A** (Phys. and Chem.), No. 2, 267-272 (Mar.-Apr. 1970).

Key words: Density of states; exciton; many body effects; phase shifts; soft x ray; transition probability.

In the study of soft x-ray transitions in solids, there has always been some hope that the results provide a direct measure of the density of states. This assumes that (a) matrix element variations over the band and (b) final state interactions are small. Both of these assumptions are now known to be incorrect. To illustrate the possible strength of these effects, two approximate calculations are presented: the one electron oscillator strength of a simple bcc metal as a function of energy; and the strength of the Nozieres—DeDominicis singularity at threshold, with phase shifts estimated from an assumed Yukawa interaction between conduction electrons and core hole.

Soft x-ray band spectra and their relationship to the density of states, G. A. Rooke, *J. Res. Nat. Bur. Stand. (U.S.)*, **74A** (Phys. and Chem.), No. 2, 273-279 (Mar.-Apr. 1970).

Key words: Alloys; auger transitions; density of states; many-body interactions; plasmons; singularities; soft x rays.

The paper concentrates on the similarities and differences between the one-electron spectrum and the density of states; many-body effects, although important, are listed but they are not considered in detail. It is shown that the only reliable information about the density of states that can be obtained from soft x-ray spectroscopy are the energies of the Fermi surface and the van-Hove singularities, although the shape of the density of states can be derived indirectly from the energies of the van-Hove singularities.

It is the differences between the density of states and the one-electron spectra that may prove to be most important. These differences can give information about the symmetry and the local nature of the screening electrons. This is particularly interesting when studying alloys.

The Li K, the Al L_{23} and the Zn L_3 spectra are given as examples which illustrate the above arguments. Finally, a brief discussion on the soft x-ray spectra from the Al-Mg system show how the results may be used to study alloys.

The electronic structure of disordered alloys, J. L. Beeby, *J. Res. Nat. Bur. Stand. (U.S.)*, **74A** (Phys. and Chem.), No. 2, 281-291 (Mar.-Apr. 1970).

Key words: Density of states; disordered alloys; one-electron propagator; perturbation expansion; sum rule.

The problem of calculating the electronic density of states in an alloy is considered from first principles. Choosing a suitably simplified model potential a diagrammatic expansion is discussed within which the various existing theories can be compared. Some comments are made on the comparison with experiment.

Summary of the conference on electronic density of states, H. Ehrenreich, *J. Res. Nat. Bur. Stand. (U.S.)*, **74A** (Phys. and Chem.), No. 2, 293-299 (Mar.-Apr. 1970).

May-June 1970

The crystal structure of hydrazinium trinitromethide, ($N_2H_5^+[C(NO_2)_3]^-$ at ~ -160 °C), B. Dickens, *J. Res. Nat.*

Bur. Stand. (U.S.), **74A** (Phys. and Chem.), No. 3, 309-318 (May-June 1970).

Key words: Crystal structure; hydrazinium; hydrazinium trinitromethide; hydrogen bonding; trinitromethide; x-ray diffraction.

The crystal structure of hydrazinium trinitromethide ($N_2H_5^+[C(NO_2)_3]^-$) has been determined using 1914 x-ray data collected photographically from a single crystal held at ~ -160 °C. The unit cell at ~ -160 °C is $a=7.91(2)$, $b=11.77(2)$, $c=13.98(2)$ Å, $\beta=104.9(3)°$, and contains eight formula weights in space group $P2_1/n$. The calculated density is 1.93 g·cm^{-3}. The structure has been refined isotropically to $R=0.10$ by full-matrix least-squares procedures. The two crystallographically independent trinitromethide anions are propeller shaped, with angles of 41°, 7°, 8°, and 74°, 5°, 4°, respectively, between the NO_2 and CN_3 plane normals. The central CN_3 part of each anion is almost planar. In one anion, the C atom is 0.008 Å out of the N_3 plane; in the other, the C atom is 0.033 Å out of the N_3 plane. Hydrogen atoms have been located approximately in an electron density difference synthesis. Their positions agree with those obtained from independent calculations involving the minimization of a function which is a first approximation to the electrostatic hydrogen bonding energy. These analyses provide evidence that one hydrazinium ion is eclipsed and the other is staggered.

A refinement of the crystal structure of $Na_2CO_3 \cdot H_2O$, B. Dickens, F. A. Mauer, and W. E. Brown, *J. Res. Nat. Bur. Stand. (U.S.)*, **74A** (Phys. and Chem.), No. 3, 319-324 (May-June 1970).

Key words: Crystal structure; hydrated carbonates; hydrogen bonding; sodium carbonate; thermonatrite; x-ray diffraction.

The crystal structure of synthetic $Na_2CO_3 \cdot H_2O$ has been refined using 1231 unique x-ray diffraction data collected by the peak height method on a diffractometer. $R=0.034$. The unit cell is $a=6.474(2)$, $b=10.724(3)$ and $c=5.259(2)$ Å with $z=4$ and space group $P2_1ab$. The calculated density is the same as the observed density, 2.26 g·cm^{-3}. The structure contains sheets of CO_3^{2-} ions bonded to Na^+ ions and water molecules roughly halfway between the sheets. Each CO_3^{2-} bonds edgewise to both Na^+ ions. The Na^+ ions have irregular but similar coordinations of seven neighbors. Each water molecule is bonded to both Na^+ ions and forms hydrogen bonds to both neighboring CO_3^{2-} layers.

Anisotropic reaction kinetics of oxygen with pyrolytic graphite, W. S. Horton, *J. Res. Nat. Bur. Stand. (U.S.)*, **74A** (Phys. and Chem.), No. 3, 325-330 (May-June 1970).

Key words: Chemical anisotropy; chemisorption; oxidation; pyrolytic graphite.

Because of the possible use of pyrolytic graphite in aerospace vehicles its reaction with oxygen-containing gases is of interest, particularly with respect to chemical anisotropy. Although several authors have found different degrees of reactivity of graphite in different directions they disagree regarding the existence of a temperature coefficient. This disagreement, however, is probably due to investigators studying single crystals in some cases and pyrolytic graphite in others and in some cases different oxidizers. New data for pyrolytic graphite are presented which were obtained by oxidizing in each run several pieces of differing geometry. These together with earlier data show that the rate ratio for the two major directions is temperature dependent with an activation energy difference of about 19 kilojoules (4500 thermochemical calories) per gram atom of carbon reacted. It is shown that this difference in rates probably arises because the relative number of sites available in these directions is sufficiently different to cause a shift in which reaction step is rate-controlling. On the "faces" chemisorption is the rate controlling step followed by rapid decomposition of surface oxides. On the "edges" decomposition is the rate controlling step. This interpretation applied to the data yield 131 kJ/mol for the activation energy of chemisorption and 150 kJ/mol for decomposition (31 and 36 kcal/mol, respectively).

The viscosity and thermal conductivity of dilute gaseous hydrogen from 15 to 5000 K, H. J. M. Hanley, R. D. McCarty, and H. Intemann, *J. Res. Nat. Bur. Stand. (U.S.)*, **74A** (Phys. and Chem.), No. 3, 331-353 (May-June 1970).

Key words: Dissociation; hydrogen; intermolecular potential functions; kinetic theory; quantum gas; thermal conductivity; viscosity.

Measurements of the viscosity and thermal conductivity of dilute gaseous para and normal hydrogen are critically evaluated and correlated by means of dilute gas kinetic theory. Numerical results are presented from 15 to 5000 K including the dissociation region.

Temperature classification of the spectra of dysprosium (Dy I, Dy II), A. S. King, J. G. Conway, E. F. Worden, and C. E. Moore, *J. Res. Nat. Bur. Stand. (U.S.)*, **74A** (Phys. and Chem.), No. 3, 355-394 (May-June 1970).

Key words: Intensity estimates, Dy spectra; dysprosium spectra, temperature classification; temperature classification, Dy I and Dy II; spectra, Dy I and Dy II.

The Temperature Classifications are listed for 4584 lines of Dy I and Dy II, as taken from an unpublished manuscript of the late A. S. King. In recording his observations, King used a wavelength list compiled mostly from the early literature. A homogeneous and extensive line list based on new observations has been prepared at the Lawrence Radiation Laboratory (LRL). King's data have been edited and adjusted by the present authors to fit the new wavelength list.

In the Table, King's estimated intensities of Dy lines in the spectra of the Arc, Spark, and Furnace are given along with the Temperature Classification. Some of his earlier published work has been used to fill the gaps in this manuscript, which was forwarded to the late W. F. Meggers in 1956.

Optical density of states ultraviolet photoelectric spectroscopy, W. E. Spicer, *J. Res. Nat. Bur. Stand. (U.S.)*, **74A** (Phys. and Chem.), No. 3, 397-415 (May-June 1970).

Key words: Copper; copper nickel alloys; density of states; GaAs; Ge; nondirect transitions; optical density of states; PbTe; ultraviolet photoemission.

The use of ultraviolet photoemission to determine the density of valence and conduction states is reviewed. Two approaches are recognized. In one, the photoemission as well as other studies are used to locate experimentally a limited number of features of the band structure. Once these are fixed, band structure calculations could be carried out throughout the zone and checked against other features of the photoemission data. If the agreement is sufficiently good, the density of states is then calculated from the band structure. The second method depends only on experimental data. Using this approach, features of the density of states are determined directly by the photoemission experiment without recourse to band calculations. In cases where bands are wide and **k** clearly provides an empirically important optical selection rule, this is possible only for portions of the bands which are relatively flat. Successful determinations of this type are cited for PbTe, and GaAs. In metals with narrow *d* bands such as Cu, it has been found empirically that one may explain fairly well the experimental energy distribution curves in terms of transitions between a density of initial and final states (the optical density of states, ODS) requiring only conservation of energy.

The ODS determined by such ultraviolet photoemission studies have more strong detailed structure than the density of states determined by any other experimental method. Studies on a large number of materials indicate that the position in energy of this structure correlates rather well with the position in energy of structure in the calculated density of states. It is suggested, following the very recent theoretical work of Doniach, that **k** conservation becomes less important (and nondirect transitions more important) as the mass of the hole becomes larger. This is due to the change in **k** of electrons in states near the Fermi level as they attempt to screen the hole left in the optical excitation process. These electrons take up the excess momentum. One would expect the **k** conservation selection rule to play an increasingly important role as the mass of the hole decreases. This is in agreement with experiment.

Beyond the one-electron approximation: Density of states for interacting electrons, L. Hedin, B. I. Lundqvist, and S. Lundqvist, *J. Res. Nat. Bur. Stand. (U.S.),* **74A** (Phys. and Chem.), No. 3, 417-431 (May-June 1970).

Key words: Density of states; interacting electrons; one-particle Green function; oscillator strengths; quasi particle density of states; x-ray emission and absorption.

The concept "density of states" can be given many different meanings when we go beyond the one-electron approximation. In this survey we concentrate on the definition tied to excitation processes, where one electron is added or removed from the solid. We discuss the one-particle spectral function for conduction and core electrons in metals, how it can be approximately calculated, and how it can be related to different types of experiments like x-ray photoemission, x-ray emission and absorption, photoemission and optical absorption in the ultraviolet, and the Compton effect. We also discuss the form of the exchange-correlation potential for use in band structure calculations.

Ion-neutralization spectroscopy, H. D. Hagstrum, *J. Res. Nat. Bur. Stand. (U.S.),* **74A** (Phys. and Chem.), No. 3, 433-441 (May-June 1970).

Key words: Auger processes; autoionization; density of states; ion-neutralization; transition probability.

The ion-neutralization spectroscopy (INS) is discussed in comparison with other spectroscopies of solids. It is shown that INS probes the local density of states of the solid at or just outside the solid surface. It is believed that this accounts for the clear-cut differences between INS results and those of other spectroscopies. Because of its unique specificity to the surface region INS is particularly useful in studying the surface electronic structures of atomically clean surfaces and of surfaces having ordered arrays of known atoms adsorbed upon them. In the latter case INS determines a portion of the molecular orbital spectrum of surface molecules formed from the adsorbed foreign atom and surface atoms of the bulk crystal. Such spectra provide information on local bonding symmetry and structure and electrical charging within the surface molecule which is as yet unavailable by any other method. INS is the first attempt to base a spectroscopy of electronic states on a two-electron process. More recent work on experimental and mathematical problems which such a spectroscopy entails are also briefly mentioned in this paper.

Local theory of disordered systems, W. H. Butler and W. Kohn, *J. Res. Nat. Bur. Stand. (U.S.),* **74A** (Phys. and Chem.), No. 3, 443-447 (May-June 1970).

Key words: Binary alloys; density of states; disordered systems; periodically continued neighborhood.

The most striking characteristic of crystalline solids is their periodicity. As a result of this feature, theoretical descriptions of physical phenomena in such systems are usually given in wave number or *momentum* space. The reciprocal lattice of a crystal and the Fermi surface of a metal are examples. In a disordered system, on the other hand, there is no such periodicity and momentum space descriptions are much less natural. However, in such systems, physical conditions near a point **r**, in *coordinate* space, become independent of the conditions at a distant point **r**′, provided that $|\mathbf{r}'-\mathbf{r}|$ is large compared to either a characteristic mean free path or some other appropriate length. This suggests that one can analyze a macroscopic disordered system by averaging over the properties of microscopic neighborhoods.

In the present paper we report some details of such a program. Although the point of view is of quite general applicability we have, for the sake of definiteness, studied so far only one type of system: Noninteracting electrons moving in the field of interacting, disordered scattering centers. We have focused especially on the electronic density of states. The macroscopic system is represented by an average over small neighborhoods. If one did not take special precautions, one would encounter one class of errors of the order of d/L where L is a characteristic dimension of the neighborhood, and d is a characteristic atomic dimension; and another class of errors of the order of $1/N$ where N is the number of ions. Both are too large to be tolerable for practical purposes. However, by an appropriate treatment of the statistical mechanics of the scatterers and by periodic repetition of the small neighborhoods, these errors can be avoided. The remaining errors are exponentially small in the ratio $\gamma(L/R)$ where γ is of order unity and R is the smaller of the electronic mean free path of the deBroglie wavelength of the electrons. This exponential convergence of the small neighborhood theory promises to make it a useful practical method for the study of disordered systems, especially very highly disordered ones.

Numerical examples are presented and discussed.

Density of states information from low temperature specific heat measurements, P. A. Beck and H. Claus, *J. Res. Nat. Bur. Stand. (U.S.),* **74A** (Phys. and Chem.), No. 3, 449-454 (May-June 1970).

Key words: Alloys; density of states; low temperature specific heat; magnetic specific heat; many-body effects; superconductivity.

The calculation of one-electron density of state values from the coefficient γ of the term of the low temperature specific heat linear in temperature is complicated by many-body effects. In particular, the electron-phonon interaction may enhance the measured γ as much as twofold. The enhancement factor can be evaluated in the case of superconducting metals and alloys. In the presence of magnetic moments, additional complications arise. A magnetic contribution to the measured γ was identified in the case of dilute alloys and also of concentrated alloys where parasitic antiferromagnetism is superimposed on an over-all ferromagnetic order. No method has as yet been devised to evaluate this magnetic part of γ. The separation of the temperature-linear term of the specific heat may itself be complicated by the appearance of a specific heat anomaly due to magnetic clusters in superparamagnetic or weakly ferromagnetic alloys.

July-August 1970

Solubility of $CaHPO_4 \cdot 2H_2O$ in the system $Ca(OH)_2 - H_3PO_4 - H_2O$ at 5, 15, 25, and 37.5 °C, T. M. Gregory, E. C. Moreno, and W. E. Brown, *J. Res. Nat. Bur. Stand.* (*U.S.*), **74A** (Phys. and Chem.), No. 4, 461-475 (July-Aug. 1970).

Key words: Calcium phosphate; dicalcium phosphate dihydrate; ion pairs; solubility; solubility isotherms; solubility product.

Solubility isotherms for $CaHPO_4 \cdot 2H_2O$, dicalcium phosphate dihydrate, DCPD. in the ternary system $Ca(OH)_2-H_3PO_4-H_2O$ were determined at 5, 15, 25. and 37.5 °C in the pH range 3.5–7; the relative positions of the isotherms indicate that DCPD has a negative thermal coefficient of solubility. The solubility product, K_s, of DCPD and the stability constants K_x and K_y for the ion pairs $[CaHPO_4^0]$ and $[CaH_2PO_4^+\}$, respectively, were obtained as functions of temperature by the use of a generalized least squares procedure subject to three condition functions—constancy of the solubility product. electrical neutrality in the solution. and congruent dissolution of the solid. The equations obtained are

$$\ln K_s = -\,8403.5/T + 41.863 - 0.09678T$$

$$\ln K_x = 51090/T - 341.14 + 0.5880T$$

$$\ln K_y = 19373/T - 122.81 +.\,0.1994T.$$

The existence of a maximum in K_s in the neighborhood of 25 °C is plausible on the basis of available thermodynamic data for DCPD. Thermodynamic functions are reported for the solution of DCPD and for the association of the ion pairs.

Effect of oxide additions on the polymorphism of tantalum pentoxide. II. "Stabilization" of the high temperature structure type, R. S. Roth, J. L. Waring, and W. S. Brower, *J. Res. Nat. Bur. Stand. (U.S.)*, **74A** (Phys. and Chem.), No. 4, 477-484 (July-Aug. 1970).

Key words: High temperature polymorph; single crystals; stabilization; tantalum oxide.

The high temperature, apparently tetragonal, polymorph of tantalum pentoxide can be obtained at room temperature by quenching a specimen containing 2-5 mole percent of the following oxides: SnO_2, Ga_2O_3, Cr_2O_3, Fe_2O_3, Sc_2O_3, or MgO. All the x-ray patterns can be indexed on a body centered tetragonal cell with $a \approx 3.830$ Å, $c \approx 35.68$ Å. However, P_2O_5, V_2O_5, Nb_2O_5, ZrO_2, Lu_2O_3, NiO, or ZnO do not stabilize the tetragonal form at room temperature. Single crystals of scandium "stabilized" Ta_2O_5 have been grown by the Czochralski technique.

Effect of oxide additions on the polymorphism of tantalum pentoxide. III. "Stabilization" of the low temperature structure type, R. S. Roth and J. L. Waring, *J. Res. Nat. Bur. Stand. (U.S.)*, **74A** (Phys. and Chem.), No. 4, 485-493 (July-Aug. 1970).

Key words: Low temperature polymorph; single crystals; stabilization; tantalum oxide.

The "low temperature structure type" of Ta_2O_5 has been found to occur in two distinct forms with the lowest temperature form having a unit cell 14 times the subcell and an intermediate temperature form with a unit cell 11 times the subcell. The two types form intermediate partially ordered mixtures which are apparently in thermal equilibrium at various temperatures between ~1000 and 1350 °C. The addition of MoO_3, WO_3, SiO_2, GeO_2, ZrO_2, TiO_2, B_2O_3 and Al_2O_3 each affect the multiplicity of the true unit cell in different ways. WO_3, SiO_2, GeO_2, B_2O_3, and Al_2O_3 form phases structurally similar to "low-Ta_2O_5" which are stable up to the solidus temperatures of the corresponding systems.

The dissociation constant of *m*-nitroanilinium ion in water-tetrahydrofuran solvents at 25 °C, R. A. Robinson, *J. Res. Nat. Bur. Stand. (U.S.)*, **74A** (Phys. and Chem.), No. 4, 495-497 (July-Aug. 1970).

Key words: Dissociation constant; ionization constant; mixed solvents; *m*-nitroaniline; tetrahydrofuran.

The dissociation constant of *m*-nitroanilinium ion has been determined in water and in six water-tetrahydrofuran mixtures. The results are compared with those for water-methanol mixtures.

Specific heats of fluorine at coexistence, R. D. Goodwin and R. Prydz, *J. Res. Nat. Bur. Stand. (U.S.)*, **74A** (Phys. and Chem.), No. 4, 499-505 (July-Aug. 1970).

Key words: Fluorine; liquid-vapor coexistence; saturated liquid; saturation; specific heats; thermodynamic properties; two-phase.

Experimental specific heats of fluorine at constant total volume are reported for the two-phase liquid-vapor system from triple- to the critical point. Specific heats of liquid along the coexistence path are derived by use of PVT data for the two-phase system, and are represented by a formula to facilitate computations of thermodynamic properties.

A theoretical investigation of the configurations $(3d+4s)^6 4p$ in neutral manganese (Mn I), C. Roth, *J. Res. Nat. Bur. Stand. (U.S.)*, **74A** (Phys. and Chem.), No. 4, 507-520 (July-Aug. 1970).

Key words: Energy levels Mn I; *g*-factors Mn I; interactions between configurations Mn I; manganese spectrum; Mn I configurations $(3d + 4s)^6 4p$.

Experimental levels of the configurations $(3d + 4s)^6 4p$ in Mn I were compared with corresponding calculated values. On fitting 228 experimental levels by means of 20 free parameters an rms error of only 170 cm^{-1} was obtained.

It was shown that the correction parameters β and T were not significant.

A literature survey of the chemistry of flame inhibition, E. C. Creitz, *J. Res. Nat. Bur. Stand. (U.S.)*, **74A** (Phys. and Chem.), No. 4, 521-530 (July-Aug. 1970).

Key words: Flame chemistry; flame extinction; flame inhibition.

Evidence is beginning to accumulate indicating that catalytic recombination of oxygen atoms may be the mechanism of extinction of flames by halogenated extinguishing agents. The literature of flame inhibition and of oxygen atom chemistry has been examined to ascertain whether the available data would support such a mechanism. Considerable sustentative evidence was found.

Kinetic rate-constant data are not available covering all reactions of interest, but those that are reported indicate that catalytic recombination of oxygen atoms can probably compete successfully with normal flame processes which require them.

The NBS Alloy Data Center: Description of index to the literature, G. C. Carter, D. J. Kahan, L. H. Bennett, J. R. Cuthill, and R. C. Dobbyn, *J. Res. Nat. Bur. Stand. (U.S.)*, **74A** (Phys. and Chem.), No. 4, 531-533 (July-Aug. 1970).

Key words: Alloy data; bibliography; index; information; Knight shifts; NMR; soft x ray.

Computerized listings of 10,000 research papers, indexed at the Alloy Data Center, are now being made available in two forms. In the first, the Permuted Materials Index, all records are arranged alphabetically by chemical symbol. Records referring to alloys or compounds are listed under each of the constituent elements. In the second, the Author Index, all papers are listed alphabetically by first author in three groupings: the first, the NMR papers; the second, the soft x-ray papers; and the third, a broad group of papers that have been of general interest to the Alloy Physics Section. The magnetic tape on which the indexed file is stored will be made available at a future date.

What is a quasi-particle?, J. R. Schrieffer, *J. Res. Nat. Bur. Stand. (U.S.)*, **74A** (Phys. and Chem.), No. 4, 537-541 (July-Aug. 1970).

Key words: Density of states; Green's function; mass enhancement; quasi-particle; superconductors.

The concept of a quasi-particle excitation in an interacting many-body system will be discussed from both the physical and the mathematical points of view. The physical origin of mass enhancement, wave function renormalization, interactions between quasi-particles, etc. will be presented. Landau's Fermi liquid theory, including the quasi-particle kinetic equation, will be reviewed. Finally, the domain of validity of the quasi-particle approximation will be discussed.

Electronic densities of states from x-ray photoelectron spectroscopy, C. S. Fadley and D. A. Shirley, *J. Res. Nat. Bur. Stand. (U.S.),* **74A** (Phys. and Chem.), No. 4, 543-558 (July-Aug. 1970).

Key words: CdCl$_2$; density of states; HgO; noble metals; rigid band model; transition metals; x-ray photoemission; ZnS.

In x-ray photoelectron spectroscopy (XPS), a sample is exposed to low energy x rays (approximately 1 keV), and the resultant photoelectrons are analyzed with high precision for kinetic energy. After correction for inelastic scattering, the measured photoelectron spectrum should reflect the valence band density of states, as well as the binding energies of several core electronic levels. All features in this spectrum will be modulated by appropriate photoelectric cross sections, and there are several types of final-state effects which could complicate the interpretation further.

In comparison with ultraviolet photoelectron spectroscopy (UPS), XPS has the following advantages: (1) the effects of inelastic scattering are less pronounced and can be corrected for by using a core reference level, (2) core levels can also be used to monitor the chemical state of the sample, (3) the free electron states in the photoemission process do not introduce significant distortion of the photoelectron spectrum, and (4) the surface condition of the sample does not appear to be as critical as in UPS. XPS seems to be capable of giving a very good description of the general shape of the density-of-states function. A decided advantage of UPS at the present time, however, is approximately a fourfold higher resolution.

We have used XPS to study the densities of states of the metals Fe, Co, Ni, Cu, Ru, Rh, Pd, Ag, Os, Ir, Pt, and Au, and also the compounds ZnS, CdCl$_2$, and HgO. The *d* bands of these solids are observed to have systematic behavior with changes in atomic number, and to agree qualitatively with the results of theory and other experiments. A rigid band model is found to work reasonably well for Ir, Pt and Au. The *d* bands of Ag, Ir, Pt, Au and HgO are found to have a similar two-component shape.

Tunneling measurements of superconducting quasi-particle density of states and calculation of phonon spectra, J. M. Rowell, *J. Res. Nat. Bur. Stand. (U.S.),* **74A** (Phys. and Chem.), No. 4, 559-565 (July-Aug. 1970).

Key words: Density of states; phonons; semiconductors; superconductivity; tunneling.

It is an unfortunate fact that the tunneling technique, which has proved incredibly successful in the study of superconductivity, has given little information about the normal state properties of metals and semiconductors. It will be shown that, in the determination of the superconducting quasi-particle density of states, it is the change in density induced by the onset of superconductivity which is measured rather than the total density.

Returning to the problem of normal materials, a review of the limited achievements and failures of tunneling will be presented. This will include the influence of band edges on tunneling in *p-n* diodes and metal-semiconductor contacts, the structures observed in tunneling into bismuth and the negative results obtained in nickel and palladium. The dominant effect of the change in barrier shape in most of these tunneling characteristics will be illustrated.

Pauli paramagnetism in metals with high densities of states, S. Foner, *J. Res. Nat. Bur. Stand. (U.S.),* **74A** (Phys. and Chem.), No. 4, 567 (July-Aug. 1970).

Relevance of Knight shift measurements to the electronic density of states, L. H. Bennett, R. E. Watson, G. C. Carter, *J. Res. Nat. Bur. Stand. (U.S.),* **74A** (Phys. and Chem.), No. 4, 569-610 (July-Aug. 1970).

Key words: Electronic density of states; hyperfine fields; Knight shift; nuclear magnetic resonance; susceptibility; wave functions.

The Knight shift, $\mathscr{K}$, measures the magnetic hyperfine field at the nucleus produced by the conduction electrons which are polarized in a magnetic field. Knight shifts are often dominated by the Pauli term and, in its most simple form, can be written as $\mathscr{K} = \langle a \rangle \chi_p$. Here χ_p is the conduction electron Pauli spin susceptibility which depends on the density of states at the Fermi level, $N(E_F)$, and $\langle a \rangle$ is an average magnetic hyperfine coupling constant associated with the wave function character at the nucleus, $|\psi_F(0)|^2$, for conduction electrons at the Fermi surface.

The Knight shift therefore provides, through $\langle a \rangle$, insight into the wave function character associated with $N(E_F)$. Calculations of $\langle a \rangle$ involving an averaging over *k*-space have been attempted for a few simple metals up to the present time. For alloys and intermetallic compounds, rather different $\langle a \rangle$'s are experimentally observed for different local environments, indicating that $\mathscr{K}$ samples the variation in *local* wave function character, or a variation in *local* density of states. There is no unique way of separating the local variation of $N(E_F)$ from $|\psi_F|(0)|^2$.

In this article the methods developed for relating $\mathscr{K}$ to the electronic properties for most of the types of cases encountered in the literature are reviewed. We discuss "simple" metals including problems of orbital magnetism and changes in $\mathscr{K}$ caused by electronic transitions such as melting. Knight shifts and their temperature dependence in metals and intermetallic compounds involving unfilled *d* shells, are discussed. We give estimates of atomic hyperfine fields due to single electrons, appropriate to those cases where problems due to electronic configurations do not make deductions from experiment too ambiguous. A density of states curve calculated for Cu is given, showing the relative importance of *s-p*, and *d* character for that metal. In a qualitative sense this Cu curve implies such information for other transition metals. We discuss alloy solid solutions for the cases where a "rigid" band model might be used to explain the results, and for cases where local effects have to be taken into account. The charge oscillation and RKKY approaches and their limitations are reviewed for cases of dilute nonmagnetic and *d*- or *f*-type impurities.

September-October 1970

Heat capacity and thermodynamic properties of α-beryllium nitride, Be$_3$N$_2$, from 20 to 315 K, G. T. Furukawa and M. L. Reilly, *J. Res. Nat. Bur. Stand. (U.S.),* **74A** (Phys. and Chem.), No. 5, 617-629 (Sept.-Oct. 1970).

Key words: Calorimeter; entropy; heat capacity; specific heat; thermodynamic properties; α-beryllium nitride.

The heat capacity of α-beryllium nitride, Be$_3$N$_2$, was determined from 20 to 315 K and the thermodynamic properties calculated from 0 to 315 K. The entropy at 298.15 K was found to be 34.4 ± 0.3 *J/K*·mol (8.23 ± 0.08 cal/K·mol). The precisio using a calorimeter of a new design is shown to be ±0.01 perce over most of the temperature range of the measurements.

Heat capacity and thermodynamic properties of β-lithium he afluoroaluminate, Li$_3$AlF$_6$, from 15 to 380 K, G. T. Furukaw

W. G. Saba, and J. C. Ford, *J. Res. Nat. Bur. Stand. (U.S.),* **74A** (Phys. and Chem.), No. 5, 631-639 (Sept.-Oct. 1970).

Key words: Calorimetry; entropy; heat capacity; thermodynamic properties; β-lithium hexafluoroaluminate.

The heat capacity of β-lithium hexafluoroaluminate, Li_3AlF_6, was determined from 15 to 380 K and the thermodynamic properties calculated from the results. The entropy at 298.15 K was found to be 187.88 ± 0.38 J/K·mol (44.904 ± 0.090 cal/K·mol).

Thermodynamics of hydrochloric acid in 80 weight percent 2-methoxyethanol and 20 weight percent water from 10 to 50 °C, H. P. Thun, B. R. Staples, and R. G. Bates, *J. Res. Nat. Bur. Stand. (U.S.),* **74A** (Phys. and Chem.), No. 5, 641-645 (Sept.-Oct. 1970).

Key words: Activity coefficients; non-aqueous emf; standard emf; thermodynamic constants for HCl transfer.

Electromotive-force measurements of cells of the type Pt, $H_2|HCl(m)$ in 2-methoxyethanol $+H_2O|AgCl$, Ag at nine temperatures ranging from 10 to 50 °C were used to derive (a) the standard emf of the cell in 80 weight percent 2-methoxyethanol (methylcellosolve), (b) the activity coefficient of HCl, (c) the relative partial molal enthalpy and heat capacity of HCl, and (d) the thermodynamic constants for the transfer of HCl from water to 80 weight percent methylcellosolve. The molality of the acid ranged from 0.006 to 0.106 mol kg^{-1}. To obtain the standard emf it was necessary to correct for ion-pair formation and to use the extended terms of the Debye-Hückel theory. The standard emf varied with temperature (t, °C) according to the equation $E_t^\circ = 0.14382 - 1.517 \times 10^{-3}t - 3.8317 \times 10^{-6}t^2 - 2.3838 \times 10^{-9}t^3$. Vapor pressures and dielectric constants for this mixture were measured over the temperature range. At 25 °C the solvent has a vapor pressure of 2506.5 Nm^{-2} (18.8 mm Hg) and a dielectric constant of 31.5.

Vapor pressure and heat of sublimation of platinum, E. R. Plante, A. B. Sessoms, and K. R. Fitch, *J. Res. Nat. Bur. Stand. (U.S.),* **74A** (Phys. and Chem.), No. 5, 647-653 (Sept.-Oct. 1970).

Key words: Heat of sublimation; Langmuir vaporization; platinum; rate of vaporiztion; vapor pressure.

The vapor pressure of platinum was measured by the Langmuir method in the temperature range 1700-2000 K using a vacuum microbalance. Eight series of data gave concordant results and an average third-law heat of sublimation of 564.49 kJ mol^{-1} with an estimated overall uncertainty of 2.1 kJ mol^{-1} (134.92 ± 0.5 kcal mol^{-1}). Three out of eight second-law heats agreed with the third-law heats within one standard error but there was a tendency for second-law heats to be low. This was attributed to small systematic errors in the measurements. A vapor-pressure equation representing the data is $\log P(\text{atm}) = -29020/T + 7.502$, based on our third-law heat and tabulated entropies evaluated at 1800 K. Our data agree well with several previous Langmuir determinations but significantly decrease the error in the heat previously accepted.

Inability to obtain saturation pressures at lower temperatures, previously reported in the literature, was confirmed. It was shown that microgram quantities of carbon are capable of blocking the sublimation reaction.

Thermophysical properties of methane: Virial coefficients, vapor and melting pressures, R. D. Goodwin, *J. Res. Nat. Bur. Stand. (U.S.),* **74A** (Phys. and Chem.), No. 5, 655-660 (Sept.-Oct. 1970).

Key words: Melting pressures; methane; thermophysical properties; vapor pressures; virial coefficients.

For use in the computation of thermodynamic properties in gaseous and liquid states at $T < 300$ K there are given concise descriptions of the properties named in the title. Numerous published data on methane are combined with some new analytical expressions which give more acceptable behavior than previously could have been achieved.

Specific heats, C_v, of compressed liquid and gaseous fluorine, R. Prydz and R. D. Goodwin, *J. Res. Nat. Bur. Stand. (U.S.),* **74A** (Phys. and Chem.), No. 5, 661-665 (Sept.-Oct. 1970).

Key words: Compressed gas; compressed liquid; fluorine; heat capacities; specific heats.

Experimental specific heats at constant volume for compressed gaseous and liquid fluorine are reported from 80 K to 300 K at pressures to about 23 MN/m^2.

Acidic dissociation of diprotonated piperazine in methanol-water solvents from 10 to 40 °C, M. Paabo and R. G. Bates, *J. Res. Nat. Bur. Stand. (U.S.),* **74A** (Phys. and Chem.), No. 5, 667-671 (Sept.-Oct. 1970).

Key words: Dissociation constant; ionization constant; methanol; mixed solvents; piperazine; pK; thermodynamics.

The first dissociation constant of piperazinium ion has been determined by the emf method in five methanol-water solvents (10 to 70 wt % MeOH) at 25 °C and in three solvents (10, 20, and 50 wt % MeOH) from 10 to 40 °C. From the variation of the dissociation constant with temperature, the changes of enthalpy, entropy, and heat capacity were derived and compared with similar data for piperazinium ion in water. The variation of pK, ΔS°, and ΔC_p° have been used to interpret the effect of the double positive charge on the solute-solvent interactions as compared to the effect exhibited by a single positive or a negative charge.

Thermal conductivity standard reference materials from 4 to 300 K. I. Armco iron: Including apparatus description and error analysis, J. G. Hust, R. L. Powell, and D. H. Weitzel, *J. Res. Nat. Bur. Stand. (U.S.),* **74A** (Phys. and Chem.), No. 5, 673-690 (Sept.-Oct. 1970).

Key words: Cryogenics; electrical resistivity; equipment; error analysis; iron; Lorenz ratio; Seebeck effect; thermal conductivity; transport properties.

An apparatus for the measurement of thermal conductivity, electrical resistivity, and thermopower of solids from 4 to 300 K is described. This apparatus, a modified version of the one used earlier in this laboratory, utilizes the steady-state, axial heat flow method. Included is a detailed discussion of the limitations of the apparatus, probable errors, and data analysis methods.

Thermal conductivity, electrical resistivity, Lorenz ratio, and thermopower data are reported for several specimens of Armco iron for temperatures from 4 to 300 K. At low temperatures the electrical resistivity and thermal conductivity vary from specimen to specimen by more than 10 percent. However, the Lorenz ratios of these specimens differ by less than 2.5 percent; and the intrinsic resistivities calculated by using Matthiessen's rule differ by less than 0.5 percent of the total resistivities. Thus, Armco iron specimens can be used as standards by measuring the residual resistivities and utilizing the Lorenz ratio reported here.

Mössbauer spectrometer calibration using TiFe, L. J. Swartzendruber and L. H. Bennett, *J. Res. Nat. Bur. Stand. (U.S.),* **74A** (Phys. and Chem.), No. 5, 691-697 (Sept.-Oct. 1970).

Key words: Calibration; chemical shift; iron; Knight shift; Mössbauer effect; sodium nitroprusside; TiFe.

The splitting of the ^{57}Fe Mössbauer spectrum in TiFe has been carefully measured in a magnetic field and compared with the zero-field quadrupolar splitting of sodium nitroprusside. The comparison gives a value of 1.699 mm/s at 295 K for the sodium nitroprusside splitting. This determination makes use of the known Knight shift of Fe in TiFe and is independent of any velocity measurement. Comparison is made with the splitting of the inner two lines of a pure Fe spectrum.

Energies of 1*snl* $(l \geq 3)$ configurations in He^4 I as calculated from polarization theory, W. C. Martin, *J. Res. Nat. Bur. Stand. (U.S.),* **74A** (Phys. and Chem.), No. 5, 699-702 (Sept.-Oct. 1970).

> Key words: Atomic energy levels; atomic theory; helium; polarizability.

The calculated singlet-triplet mean energies are given for all He^4 I configurations having $3 \leq l \leq n-1$ from 4*f* to 8*k*. Since only Stark-shifted transitions have been observed for such configurations with $l \geq 4$, the calculated positions are the most accurate available. The polarization energy (to the quadrupole approximation) for two-electron ions may be evaluated for higher *nl* or *Z* from the simple formulas. The calculated and observed positions of the 1*snf* configurations in He^4 I and Li^7 II agree within the experimental uncertainties.

A theoretical investigation of the configurations $(3d+4s)^8 4p$ in neutral cobalt (Co I), C. Roth, *J. Res. Nat. Bur. Stand. (U.S.),* **74A** (Phys. and Chem.), No. 5, 703-713 (Sept.-Oct. 1970).

> Key words: Cobalt; configurations $(3d+4s)^8 4p$; energy levels; *g*-factors; interactions between configurations.

Experimental levels of the configurations $(3d+4s)^8 4p$ were compared with corresponding calculated values. On fitting 154 levels by means of 19 free parameters an rms error of only 164 cm^{-1} was obtained.

Odd configurations in neutral nickel (Ni I), C. Roth, *J. Res. Nat. Bur. Stand. (U.S.),* **74A** (Phys. and Chem.), No. 5, 715-722 (Sept.-Oct. 1970).

> Key words: Energy levels; *g*-factors; interactions between configurations; nickel; $(3d+4s)^9 4p$; $3d^9 4p + 3d^8 4s4p + 3d^9 5p$.

Experimental levels of the configurations $3d^9 4p$, $3d^8 4s4p$ and $3d^9 5p$ of Ni I were compared with corresponding calculated values. The electrostatic interactions between the configurations $(3d+4s)^9 4p$ as well as between $3d^8 4s4p$ and $3d^9 5p$ were considered explicitly.

For the configuration $(3d+4s)^9 4p$, 71 experimental levels were fitted by means of 17 free parameters to yield an rms error of 131 cm^{-1}. On fitting 83 levels of the configurations $3d^9 4p + 3d^8 4s4p + 3d^9 5p$ by means of 25 free parameters an rms error of 147 cm^{-1} was obtained.

Electron-spin resonance study of an alkaline solution of copper(II) oxalate-*meso*-tartrate complex (the Somogyi reagent) and related complexes, A. J. Fatiadi, *J. Res. Nat. Bur. Stand. (U.S.),* **74A** (Phys. and Chem.), No. 5, 723-731 (Sept.-Oct. 1970).

> Key words: Alkaline; complex; copper, e.s.r.; ligand; paramagnetic; reagent; spectra; structure; superoxide.

Electron-spin resonance (e.s.r.) studies of the structure of four reagents commonly used in the carbohydrate field, namely, the Somogyi reagent, the Fehling reagent, the Benedict reagent, and the Reeves reagent, in frozen aqueous solution at 77 K, gave definite indications of dimer in the Fehling reagent only; the Benedict reagent contains a relatively low concentration of dimer as compared to monomer. The presence of an "extra" peak at 3.245 kgauss in the e.s.r. spectrum of the Somogyi reagent at 25 °C may be associated with a paramagnetic, superoxide, ion-ligand O_2^-; at 77 K, extra peaks were observed for the Somogyi, Fehling, and Benedict reagents.

November-December 1970

***PVT* measurements, virial coefficients, and Joule-Thomson inversion curve of fluorine,** R. Prydz and G. C. Straty, *J. Res. Nat. Bur. Stand. (U.S.),* **74A** (Phys. and Chem.), No. 6, 747-760 (Nov.-Dec. 1970).

> Key words: Isochores; isotherms; Joule-Thomson inversion curve; liquid densities along melting line; PVT data; second virial coefficient; third virial coefficient.

Experimental *PVT* measurements on gaseous and liquid fluorine from the triple point (53.5 K) to 300 K at pressures to about 21 MN/m^2 are presented. The data are represented by a truncated virial equation in the low-density region. Comparisons of the second virial coefficient from this equation are made with published data. The *PVT* relationship along the Joule-Thomson inversion curve was obtained from the isotherm-isochore representation of the high density region.

The activity coefficients of hydrofluoric acid in water from 0 to 35 °C, W. J. Hamer and Y.-C. Wu, *J. Res. Nat. Bur. Stand. (U.S.),* **74A** (Phys. and Chem.), No. 6, 761-768 (Nov.-Dec. 1970).

> Key words: Activities of HF; equilibrium constant of HF dissociation; ionic concentrations in HF; pH values of HF.

The mean stoichiometric activity coefficients of hydrofluoric acid in aqueous solutions have been calculated from measurements of electrolytic conductivity, the electromotive forces of galvanic cells without liquid junction, and the freezing-point depression. Values obtained from freezing-point depressions were converted to values for 25 °C using known values of the heats of dilution and apparent molal heat capacities of aqueous solutions of hydrofluoric acid of various concentrations. It is also shown that values for the concentrations of the various ionic species in hydrofluoric acid, namely, H^+, F^-, HF_2^-, and HF depend on the functions used to represent the ionic activity coefficients whereas values of the mean activity, $a_{H^+}a_{F^-}$, are independent of such functions. Values of the pH of various concentrations of hydrofluoric acid are given for temperatures of 0 to 35 °C; these, likewise, are nearly independent of activity-coefficient function used to obtain values for the ionic concentrations.

Fluorine flame calorimetry III. The heat of formation of chlorine trifluoride at 298.15 K, R. C. King and G. T. Armstrong, *J. Res. Nat. Bur. Stand. (U.S.),* **74A** (Phys. and Chem.), No. 6, 769-779 (Nov.-Dec. 1970).

> Key words: Bond energy (Cl — F); chlorine reaction with hydrogen; chlorine trifluoride, heat of formation; flame calorimetry; flow calorimetry; fluorine compounds; heat of formation; heat of reaction; hydrogen chloride (aqueous), heat of formation; mixed acids; $(HCl + 3HF)_{aq}$, heat of formation; reaction calorimetry; reaction with hydrogen.

The standard heat of formation of chlorine trifluoride (gas) at 298.15 K has been determined to be − 164.65 kJ mol^{-1} (− 39.35 kcal mol^{-1}) with an overall experimental uncertainty of 5.14 kJ mol^{-1} (1.23 kcal mol^{-1}). This value is derived from the enthalpies of the following reactions which were measured directly in a flame calorimeter operated at 1 atm pressure and 303.5 K, together with data from previous investigations.

$$ClF_3(g) + 2H_2(g) + 100H_2O(l) \rightarrow [HCl \cdot 3HF \cdot 100H_2O](l)$$

$$(1/2)Cl_2(g) + 1/2H_2(g) + [3HF \cdot 100H_2O](l) \rightarrow [HCl \cdot 3HF \cdot 100H_2O](l)$$

The enthalpy of formation of $[HCl \cdot 100H_2O](l)$ was also measured. The average Cl — F bond energy in chlorine trifluoride is calculated to be 160.1 kJ mol^{-1} (38.26 kcal mol^{-1}).

A review of oscillator strengths for lines of Cu I, C. H. Corliss, *J. Res. Nat. Bur. Stand. (U.S.)*, **74A** (Phys. and Chem.), No. 6, 781-790 (Nov.-Dec. 1970).

Key words: Atomic spectra; copper; Cu I; oscillator strengths; spectral lines of Cu I.

New determinations of oscillator strengths made by Kock and Richter provide for the first time reference standards which permit the adjustment of five previous sets of measurements to an improved scale of absolute oscillator strengths for lines of Cu I. Critical discussions of the several sets of measurements and a consistent list of values for 272 lines in the region 2024 to 8092 Å are presented.

Stark effect and hyperfine structure of HCN measured with an electric resonance maser spectrometer, H. E. Radford and C. V. Kurtz, *J. Res. Nat. Bur. Stand. (U.S.)*, **74A** (Phys. and Chem.), No. 6, 791-799 (Nov.-Dec. 1970).

Key words: Dipole moment; HCN resonance spectrum; maser spectrometer; Stark effect; voltage standard.

The 449 MHz *l*-type doubling spectrum of HCN has been measured to high precision with a molecular beam maser spectrometer. Hyperfine structure due to both the nitrogen nucleus and the proton was resolved, and the coupling constant of the proton $\mathbf{I}\cdot\mathbf{J}$ interaction was found to be -27.3 ± 1.6 kHz. The spectrometer is also suited to precise measurements of Stark effects in molecules of the linear and symmetric top variety, and Stark shifts of up to 10^4 times the zero-field line width have been measured in the HCN spectrum. Analysis of these measurements yields the value $\mu=2.940\pm0.001$ D for the dipole moment of the $\epsilon_2=1$ state of HCN.

The second spectrum of nickel (Ni II), A. G. Shenstone, *J. Res. Nat. Bur. Stand. (U.S.)*, **74A** (Phys. and Chem.), No. 6, 801-855 (Nov.-Dec. 1970).

Key words: Energy levels; ionization potential; nickel; spectral series; spectroscopy; wavelength.

An analysis of Ni II based on 4300 observed lines is presented. The low structures are $3d^9$, $3d^84s$ and $3d^74s^2$ which are now complete except for $3d^8(^1\mathrm{S})4s\,^2\mathrm{S}$ and $3d^74s^2\ ^2\mathrm{P}_{1/2}$ and the higher of the two $^2\mathrm{D}$ terms of $3d^74s^2$. Long series occur such as $3d^84s$ to $9s$, $4d$ to $8d$, $4f$ to $7f$, $5g$ to $7g$. The analysis also includes many terms of the complex structure $3d^74s4p$ but only 55 percent of the levels within reach of the hollow cathode source have been found. The identification of the levels of $3d^84d$ and $5d$ was assisted by the calculations of N. Spector. The $4d^74s^2$ levels were calculated by Y. Shadmi, who also provided calculated positions for all the levels of $3d^74s4p$ without which much of the analysis would have been impossible. The $3d^8ns$ and $3d^8nd$ series give a limit of 146532.0 but the $3d^8ng$ series give 146541.56. The latter has been adopted though no explanation of the discrepancy has been found.

3.2. PAPERS FROM THE JOURNAL OF RESEARCH OF THE NATIONAL BUREAU OF STANDARDS, SECTION B. MATHEMATICAL SCIENCES, VOLUME 74B, JANUARY-DECEMBER 1970

January-March 1970

Partitions—a survey, H. Gupta, *J. Res. Nat. Bur. Stand. (U.S.),* **74B** (Math. Sci.), No. 1, 1-29 (Jan.-Mar. 1970).

Key words: Congruences; generating functions; identities; partitions; recurrence formulas.

A historical survey of some aspects of the theory of partitions is given here.

A relation between the coefficients and roots of two equations and its application to diophantine problems, T. N. Sinha, *J. Res. Nat. Bur. Stand. (U.S.),* **74B** (Math. Sci.), No. 1, 31-36 (Jan.-Mar. 1970).

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

The object of this paper is to prove:

THEOREM 1: *The system of equations*

$$a_1^r + a_2^r + \ . \ . \ . \ + a_n^r = b_1^r + b_2^r + \ . \ . \ . \ + b_n^r (r = 1, 2, \ . \ . \ ., j-1, j+1, \ . \ . \ ., n+1)$$

where j *is odd, has no nontrivial solutions in positive integers.*

THEOREM 2: *No two equations* $a_1^r + a_2^r = b_1^r + b_2^r (r = s, t)$ *where the pairs of values of* r *range between* 1 *and* 4 *can have a nontrivial solution in integers.*

An enumeration problem for a congruence equation, R. A. Brualdi and M. Newman, *J. Res. Nat. Bur. Stand. (U.S.),* **74B** (Math. Sci.), No. 1, 37-40 (Jan.-Mar. 1970).

Key words: Circulants; congruences; permanents.

It is shown that the number of n-tuples $(x_0, x_1, \ldots, x_{n-1})$ of nonnegative integers such that

$$\sum_{i=0}^{n-1} x_i = \mathrm{n},$$

$$\sum_{i=0}^{n-1} ix_i \equiv 0 \bmod n,$$

is given by

$$\frac{1}{n}\sum_{d|n}\binom{2d-1}{d}\varphi\left(\frac{n}{d}\right).$$

Orthogonal decompositions of tensor spaces, S. Pierce, *J. Res. Nat. Bur. Stand. (U.S.),* **74B** (Math. Sci.), No. 1, 41-44 (Jan.-Mar. 1970).

Key words: Irreducible character; symmetry class of tensors; symmetry operator; tensor product.

Let V be an n-dimensional vector space over the complex numbers. Let H be a subgroup of S_m, the symmetric group on $\{1, \ldots, m\}$, and let $W = \overset{m}{\underset{1}{\otimes}} V$ be the tensor product of V with itself m times. In this note we give an orthogonal direct sum decomposition of W in terms of the system of inequivalent irreducible characters of H.

AMS Subject Classifications: Primary, 1580; Secondary, 2080.

Partitioned hermitian matrices, R. Merris, *J. Res. Nat. Bur. Stand. (U.S.),* **74B** (Math. Sci.), No. 1, 45-46 (Jan.-Mar. 1970).

Key words: Generalized matrix function; positive semidefinite hermitian matrix.

A class of Cauchy-Schwarz type inequalities for partitioned hermitian matrices is presented.

Bounds on a polynomial, T. J. Rivlin, *J. Res. Nat. Bur. Stand. (U.S.),* **74B** (Math. Sci.), No. 1, 47-54 (Jan.-Mar. 1970).

Key words: Bernstein polynomials; bounds; polynomials.

Methods for computing the maximum and minimum of a polynomial with real coefficients in the interval [0,1] are described, and certain bounds are given.

Entire functions of exponential type, F. Gross, *J. Res. Nat. Bur. Stand. (U.S.),* **74B** (Math. Sci.), No. 1, 55-59 (Jan.-Mar. 1970).

Key words: Bounded index; convexity; entire function; exponential type; maximum modulus.

Let f be an entire function satisfying for some integer p and some constant C

$$\sum_{j=0}^{N}\left(\int_0^{2\pi} / f^{(j)}(\mathrm{r}e^{i\theta})/^p d\theta\right)^{1/p} \geqslant C \sum_{j=N+1}^{\infty}\left(\int_0^{2\pi} / f^{(j)}(\mathrm{r}e^{i\theta}) /^p\right)^{1/p}$$

for sufficiently large r. Then f is of exponential type. Conversely, the above is satisfied whenever f is periodic of exponential type. Similar conditions on the maximum moduli $M_f(j)\,(r)$ yield the same result. The analogous condition on $|f^{(j)}|$ is also discussed.

April-June 1970

Acoustic propagation and stability within an inviscid, heat-conducting fluid, J. E. McKinney and H. J. Oser, *J. Res. Nat. Bur. Stand. (U.S.),* **74B** (Math. Sci.), No. 2, 67-84 (Apr.-June 1970).

Key words: Absorption; acoustic; adiabatic; fluid; heat-conducting; inviscid; isothermal; Kirchoff-Langevin equation; stability; steady-state; thermal; transient.

Propagation of acoustic waves within a continuum of inviscid, compressible, heat-conducting fluid is evaluated in detail in terms of both frequency (steady-state) and time dependent (transient) functions. The analysis reveals that when the value of the ratio of specific heats, γ, lies between one and two, the apparent steady-state solutions are conjugate to unstable, or regenerative, "transient" solutions, and, thus, are unacceptable. Propagation is stable for other values ($\gamma = 1, \gamma \geqslant 2$). The common assumption that the steady-state phase velocity varies continuously with increasing frequency from adiabatic to isothermal values is shown to be invalid, except when $\gamma = 2$.

On some indefinite integrals of confluent hypergeometric functions, E. W. Ng and M. Geller, *J. Res. Nat. Bur. Stand. (U.S.),* **74B** (Math. Sci.), No. 2, 85-98 (Apr.-June 1970).

Key words: Bessel functions; confluent hypergeometric functions; electronic energies; indefinite integrals.

Analytical expressions and reduction formulas are developed for various indefinite integrals of the confluent hypergeometric functions. These integrals are of the type $\int f(a,b,z)z^p e^{\alpha z}dz$, where f is one of the two Kummer functions $M(a,b,z) \equiv {}_1F_1(a;b;z)$ or $U(a,b,z)$, with real or complex a, b, z and α, and real p.

On complementary polar conical sets, C. Witzgall, *J. Res. Nat. Bur. Stand. (U.S.),* **74B** (Math. Sci.), No. 2, 99-113 (Apr.-June 1970).

Key words: Conjugate functions; convex cones; duality; linear programming; orthogonality; polarity.

Tucker has formulated the Duality Theorem of Linear Programming in terms of orthogonality properties of a pair of complementary orthogonal linear manifolds with respect to the positive orthant. This theorem is generalized by substituting complementary polar conical sets for complementary orthogonal linear manifolds, and the generalization is proved under simple stability assumptions. Equivalence to Fenchel's Duality Theorem for conjugate convex functions is established. There are strong parallelisms to work by Kretschmer.

On contractive semigroups and uniform asymptotic stability, P. R. Meyers, *J. Res. Nat. Bur. Stand. (U.S.),* **74B** (Math. Sci.), No. 2, 115-120 (Apr.-June 1970).

Key words: Contractions; control theory; functional analysis; semigroup; stability theory; topology.

This paper calls attention to the equivalence between two well-known mathematical ideas: contraction mappings (in the sense of Banach) and asymptotic stability. The equivalence is formalized by defining a flow (representing the possible movements over time of some system through its state space) as a continuous one-parameter semigroup of operators on a metric space, and then showing that these operators are all contractions (in suitably revised metrics) if and only if there is a uniformly asymptotically stable equilibrium point. Generalizations to other operator semigroups are also given.

Normal subgroups of the modular group, L. Greenberg and M. Newman, *J. Res. Nat. Bur. Stand. (U.S.),* **74B** (Math. Sci.), No. 2, 121-123 (Apr.-June 1970).

Key words: Genus; index; modular group; normal subgroups.

A number of results on the normal subgroup structure of the classical modular group is announced. A typical result is that a normal subgroup of square-free index is necessarily of genus 1, apart from 4 exceptions.

July-September 1970

Hecke basis theorems for groups of genus 0, M. I. Knopp and J. R. Smart, *J. Res. Nat. Bur. Stand. (U.S.),* **74B** (Math. Sci.), No. 3, 131-148 (July-Sept. 1970).

Key words: Eisenstein series; Hecke group; H-group; modular form; parametrization of cusp forms.

A Hecke-type basis theorem is established for the cusp forms of negative even integral degree (multiplier system 1) on the class of Hecke groups. Hecke established the result for the classical modular group, which is the first of the Hecke groups. A second result is a parametrization theorem for entire automorphic forms of negative real degree (with arbitrary multiplier systems) on certain discrete groups of real linear fractional transformations of genus zero.

The distribution of eigenvalues of covariance matrices of residuals in analysis of variance, J. Mandel, *J. Res. Nat. Bur. Stand. (U.S.),* **74B** (Math. Sci.), No. 3, 149-154 (July-Sept. 1970).

Key words: Analysis of variance; covariance matrix; eigenvalues; interaction; matrix; residuals; two-way table; vacuum cleaner.

A rigorous definition is given for the concept of an "interaction matrix" (Z_{ij}) where $i=1$ to m and $j=1$ to n, in terms of two idempotent matrices A_r and B_s of rank r and s, respectively. It is then shown that the frequency distribution of the eigenvalues of $(Z)(Z)'$ depends only on r and s. Applications are given to matrices of residuals arising from two-way data, either by removing row and/or column-means, or by applying any number of sweeps of the "vacuum cleaner." The theorems are important in the theory of the analysis of two-way tables of nonadditive data.

Expansions with coefficient algorithms for time domain responses of skin effect lossy coaxial cables, D. R. Holt, *J. Res. Nat. Bur. Stand. (U.S.),* **74B** (Math. Sci.), No. 3, 155-173 (July-Sept. 1970).

Key words: Coefficient algorithms; expansions; inverse Laplace transform; reflectometry; skin effect; step response; system function; transmission.

Time domain step response expansions with coefficient algorithms are developed from the system function of a doubly terminated skin effect lossy coaxial transmission line. Three models of series impedance valid for (a) high frequency, (b) high and intermediate frequency, (c) high and low frequency, are incorporated into the system function. The system function is expanded via the method of polynomial expansions of analytic functions through generating relations and inverted term by term into the time domain through the inverse Laplace transform. Step responses for time domain reflectometry and transmission are developed, computed, and compared with experimental results.

Derivatives of the Grüneisen and Einstein functions, A. Cezairliyan, *J. Res. Nat. Bur. Stand. (U.S.),* **74B** (Math. Sci.), No. 3, 175-182 (July-Sept. 1970).

Key words: Einstein function; electrical resistivity; Grüneisen function; solid state physics; transport properties.

Expressions (in closed form) are derived for the first five derivatives of the Grüneisen and Einstein functions. Recursion formulas for the successive derivatives of both functions are also given. Computations are made and tabular results are given for the first five derivatives of the Grüneisen and Einstein functions.

Selecting nonlinear transformation for the evaluation of improper integrals, T. A. Atchison, *J. Res. Nat. Bur. Stand. (U.S.),* **74B** (Math. Sci.), No. 3, 183-185 (July-Sept. 1970).

Key words: Improper integral; nonlinear transformation.

Recent literature concerning the use of nonlinear transformations to evaluate numerically certain improper integrals of the first kind involves the determination of a transformation function g to improve the approximation. By approximating a given integrand f by an integrable function f_1 and then determining an associated g function for f_1, a nonlinear transformation may be constructed which will yield an improved approximation of the improper integral of f.

On the spheroidal functions, D. R. Rhodes, *J. Res. Nat. Bur. Stand. (U.S.),* **74B** (Math. Sci.), No. 3, 187-209 (July-Sept. 1970).

Key words: Mathieu functions; spheroidal functions.

A number of new properties of the spheroidal functions of arbitrary real order $\alpha > -1$ are established, including double orthogonality over two separate intervals simultaneously and the existence of a new kind of characteristic numbers $\gamma_{\alpha n}(c)$ that arise from it. Some computational formulas are derived and a few numerical results are shown.

Automatic computing methods for special functions, I. A. Stegun and R. Zucker, *J. Res. Nat. Bur. Stand. (U.S.),* **74B** (Math. Sci.), No. 3, 211-224 (July-Sept. 1970).

Key words: Approximations; computer programs; computing pitfalls; continued fractions; error function; recurrence relations; series.

Some of the pitfalls of automatic computation are described as well as their possible avoidance. A detailed description is given of the methods for computing the error and complementary error function. The implementation of the method is given in a double precision ASA FORTRAN program. The test ("driver") program and test results are also given.

October-December 1970

A property of the triangle groups, J. Lehner, *J. Res. Nat. Bur. Stand. (U.S.),* **74B** (Math. Sci.), No. 4, 231-233 (Oct.-Dec. 1970).

Key words: Element of finite order; *F*-group; normal subgroup; triangle group.

The *F*-groups are the groups possessing faithful representations by Fuchsian groups of the first kind; their presentations are known explicitly. Among the *F*-groups are the well-known triangle groups $G=\{x, y|x^p=y^q=(xy)^r=1\}$. If p, q, r are distinct prime integers, every proper normal subgroup of finite index in G has no elements of finite order. In this paper it is proved that among the *F*-groups only the triangle groups with distinct prime p, q, r have this property.

Some theorems on tensor composite graphs, M. F. Capobianco, *J. Res. Nat. Bur. Stand. (U.S.),* **74B** (Math. Sci.), No. 4, 235-237 (Oct.-Dec. 1970).

Key words: Digraphs; graphs; products; tensor; trees.

If a graph (digraph) is isomorphic to the tensor product of two graphs (digraphs) it is said to be a tensor composite graph (digraph). If not, it is said to be tensor prime. Several theorems giving various properties of tensor composite graphs and digraphs are presented. Among those dealing with (undirected) graphs is the result that any tree is tensor prime. This does not hold for digraphs. An example is given of a tensor composite digraph which is an unoriented tree. It is proved that a tensor composite digraph which is an oriented tree (an arborescence) does not exist. Some applications are presented.

The diophantine approximation of roots of positive integers, C. F. Osgood, *J. Res. Nat. Bur. Stand. (U.S.),* **74B** (Math. Sci.), No. 4, 239-242 (Oct.-Dec.).

Key words: Diophantine approximation; diophantine equation; effective computability.

The following result is established:

THEOREM: *Suppose that* $k \geqslant 150$ *and* m *are fixed positive integers. Then*

$$|\sqrt[k]{m}=pq^{-1}|<q^{-\frac{7}{8}k} \qquad .$$

can hold for at most one pair of relatively prime positive integers p *and* q *with* $q \geqslant 2^9(\sqrt[k]{m+1})^6$.

The new feature of this result is that the lower bound on q is given explicitly and is "small."

The minimum number of problems to cover all subproblems, H. J. Greenberg, *J. Res. Nat. Bur. Stand. (U.S.),* **74B** (Math. Sci.), No. 4, 243-247 (Oct.-Dec. 1970).

Key words: Combinatorics; dynamic programming; optimization; systems of distinct representatives; theory of computation.

The following problem is motivated and then solved, using the theory of systems of distinct representatives. Let $M=\{1, 2, \ldots, m\}$, and for each sequence σ of distinct members of M, let $\langle\sigma\rangle$ be the associated subset. Suppose given a mathematical problem $P(S)$ for each subset S of M, and an algorithm A which when applied to σ solves not only $P(\langle\sigma\rangle)$ but also all $P(\langle\tau\rangle)$ where τ is an initial segment of σ. What is the smallest number of applications of A needed to solve the entire ensemble of problems $\{P(S):S \subset M\}$?

Error estimates for the solution of linear algebraic systems, Brother K. E. Fitzgerald, F.S.C., *J. Res. Nat. Bur. Stand. (U.S.),* **74B** (Math. Sci.), No. 4, 249-306 (Oct.-Dec. 1970).

Key words: Error estimates; evaluation of computer programs; inverse of a matrix; linear systems and matrices.

In this paper bounds for the error of a computed inverse of a matrix are developed. These are then applied to the solution of a single system. Methods for improving the approximate inverse are then discussed with some observations on the dangers involved in their practical use on a computer and some safeguards are indicated. Some computer programs for matrix inversion are then evaluated by means of the bounds developed.

On the singular values of a product matrices, W. Watkins, *J. Res. Nat. Bur. Stand. (U.S.),* **74B** (Math. Sci.), No. 4, 307-309 (Oct.-Dec. 1970).

Key words: Matrices; singular values.

The purpose of this note is to give necessary and sufficient conditions for the singular values of a product of matrices to be equal to certain products of their singular values. We then analyze the case of equality in a matrix inequality of Ostrowski.

Contractifiable semigroups, P. R. Meyers, *J. Res. Nat. Bur. Stand. (U.S.),* **74B** (Math. Sci.), No. 4, 311-319 (Oct.-Dec. 1970).

Key words: Contractions; functional analysis; operators; semigroups; stability theory.

Consider a continuous semigroup of operators on a metric space, indexed $\{T_t\}$ by the nonnegative real numbers. It is shown that if any one of the operators can be made into a contraction by some topology-preserving remetrization, then for each $\lambda\epsilon(0, 1)$ there is a metric under which each operator $T_t(t>0)$ becomes a contraction constant λ^t. With the operators regarded as describing the evolution of an autonomous dynamical system, this metric can be used to define a Lyapanov function.

3.3. PAPERS FROM THE JOURNAL OF RESEARCH OF THE NATIONAL BUREAU OF STANDARDS, SECTION C. ENGINEERING AND INSTRUMENTATION, VOLUME 74C, JANUARY-DECEMBER 1970

January-June 1970

Production of near-perfect interferograms of variable visibility, J. B. Saunders, *J. Res. Nat. Bur. Stand. (U.S.)*, **74C** (Eng. and Instr.), Nos. 1 and 2, 1-2 (Jan.-June 1970).

Key words: Interference fringes; interferograms.

A method is given for producing interferograms of fringes that are straight and equally spaced. The intensity distribution obeys the cosine law. The visibility can be controlled over the entire range from zero to unity. The interferometer is rugged and practically free from vibration effects.

Locked nuclear quadrupole resonance spectrometer for pressure measurements, R. C. Frisch and D. L. VanderHart, *J. Res. Nat. Bur. Stand. (U.S.)*, **74C** (Eng. and Instr.), Nos. 1 and 2, 3-8 (Jan.-June 1970).

Key words: KClO$_3$ nuclear quadrupole resonance; pressure transducer; spectrometer.

The Nuclear Quadrupole Resonance frequency of a nucleus in a solid is dependent on its local environment and can be quite sensitive to changes in temperature and pressure. A spectrometer capable of locking accurately to the center of a resonance signal is described. The feasibility of using the quadrupole resonance frequency as a transfer gage for precise pressure measurements is discussed using ^{35}Cl resonance in a KClO$_3$ polycrystalline sample. The performance of the instrument implies a limiting accuracy for pressure measurements of 0.7 bar; preliminary results are presented showing frequency versus pressure near room temperature. Uncertainties of these measurements are primarily due to inadequate temperature control and the uncertainty of the pressure measurement.

Precise continuous optical attenuator, G. Ruffino, *J. Res. Nat. Bur. Stand. (U.S.)*, **74C** (Eng. and Instr.), Nos. 1 and 2, 9-13 (Jan.-June 1970).

Key words: Dichroic polarizers; optics; pyrometry; radiometry; relative transmittance factor.

The construction of a precision photometric attenuator is described, which uses linear birefringent polarizers. If properly calibrated, the instrument has relative error not exceeding 2.4×10^{-4} within a relative transmittance range down to 8×10^{-3}. The calibration takes into account stray light, provided the ratio of stray light intensity to total intensity remains constant and low in the whole range. The construction and calibrating procedure apply equally well to the near infrared region.

An a-c resistance thermometer bridge, R. D. Cutkosky, *J. Res. Nat. Bur. Stand. (U.S.)*, **74C** (Eng. and Instr.), Nos. 1 and 2, 14-17 (Jan.-June 1970).

Key words: Automatic phase balance; bridge; multistage transformers; operational amplifiers; resistance bridge; resistance thermometry; temperature measurement.

A 400 Hz bridge designed specifically for measuring the resistances of platinum thermometers is described. When used in conjunction with a conventional 25 ohm thermometer, the instrument can resolve a resistance change of 2 micro-ohms or less, or about 20 microdegrees. It is believed to be in error by no more than 3 micro-ohms throughout the useful temperature range of a conventional thermometer. The instrument features an automatic phase angle balance, and extensive use is made of multistage transformers and operational amplifiers.

On the flow induced by a Maxwell-Chartoff rheometer, E. A. Kearsley, *J. Res. Nat. Bur. Stand. (U.S.)*, **74C** (Eng. and Instr.), Nos. 1 and 2, 18-19 (Jan.-June 1970).

Key words: Normal stresses; rheology; rheometer; viscoelasticity.

The Maxwell-Chartoff rheometer does not supply the surface tractions necessary to maintain the flow customarily assumed. This can be seen from considerations of the energy balance.

Mechanical compliance measurements of single-edge-notch tension specimens, M. J. Orloski, *J. Res. Nat. Bur. Stand. (U.S.)*, **74C** (Eng. and Instr.), Nos. 1 and 2, 20-26 (Jan.-June 1970).

Key words: Compliance; crack-toughness; fracture; single-edge-notch specimen.

This paper describes the mechanical compliance measurement of a 15×3-in single-edge-notch (SEN) specimen, effective gage length greater than twice specimen width, and a 7×3-in SEN specimen, effective gage length less than twice specimen width, both of 1/4-in-thick 7075 − T6 aluminum. The 15×3-in specimen was chosen to provide experimental values of EWG/P^2 for comparison with the theoretical stress function solutions of Srawley and Gross. Results obtained are in good agreement with the theoretical values. The 7×3-in specimen was chosen as proportional to a practical size SEN specimen that has been widely used. Comparisons of experimental values of EWG/P^2 for this specimen were made with these theoretical stress function solutions.

Effect of notch geometry and temperature on the creep-rupture behavior of titanium alloy, W. D. Jenkins and W. A. Willard, *J. Res. Nat. Bur. Stand. (U.S.)*, **74C** (Eng. and Instr.), Nos. 1 and 2, 27-37 (Jan.-June 1970).

Key words: Creep; elevated temperature; engineering design; notch geometry; stress concentration; stress-rupture; titanium alloy.

Creep-rupture tests were made on circumferentially notched Ti-8Al-1Mo-1V specimens at temperatures of 600, 800, 1000, and 1200 °F (588, 699, 811, and 921 K) with stresses to produce rupture times ranging from 1 min to several thousand hours. A comprehensive study was made to determine the effects of notch geometry (angle, depth, root radius) on creep, rupture, and ductility characteristics of the alloy. Although a limited first stage and well-defined second and third stages of creep were observed, neither rupture times nor reduction of area values were predictable from extension-time behavior. Rupture time and ductility appeared to be affected more by the initial root radius at the base of the notch than by notch depth. Differences in mechanical behavior between specimens of different notch geometries were less as the temperature was increased or the stress decreased. A limited number of tests indicated that prior strain history had a marked effect on subsequent creep-rupture behavior at 1000 °F.

Relative amounts of alpha and beta constituents, the number of observed internal cracks, and the mode of fracture were affected by notch geometry and test temperatures.

July-December 1970

Techniques for comparing four-terminal-pair admittance standards, R. D. Cutkosky, *J. Res. Nat. Bur. Stand. (U.S.),* **74C** (Eng. and Instr.), Nos. 3 and 4, 63-78 (July-Dec. 1970).

Key words: AC direct-reading ratio set; ac measurements; bridge; coaxial chokes; defining transformers; equal power bridge; four-pair standards; frequency-dependent bridge; quadrature bridge.

Some of the advantages of four-pair admittance standards and some of the special problems encountered in their measurement are pointed out. Detailed descriptions of three distinct types of four-pair bridges and some of their limitations are presented. These three bridges form a vital part of a very precise absolute measurement of resistance based on a calculable capacitor being undertaken at the National Bureau of Standards, but are believed to be of more general usefulness.

Some applications for series impedance elements in radio frequency immittance measurements, L. E. Huntley, *J. Res. Nat. Bur. Stand. (U.S.),* **74C** (Eng. and Instr.), Nos. 3 and 4, 79-85 (July-Dec. 1970).

Key words: Immittance measurement; radio frequency; series elements; two-port standards.

A series impedance element equipped with coaxial connectors may be evaluated as a two-port network. Precision connectors greatly reduce the uncertainties associated with the series connection, making practical several measurement techniques which involve series impedances. This paper discusses techniques for extending the range of immittance bridges to high values of admittance or impedance, for measuring very small admittances with incremental standards of ordinary range, and for using a bridge to measure its own reference open-circuit admittance or short-circuit impedance.

A pulse heating method for the measurement of melting point of electrical conductors (thin wires) above 2000 K, A. Cezairliyan, *J. Res. Nat. Bur. Stand. (U.S.),* **74C** (Eng. and Instr.), Nos. 3 and 4, 87-88 (July-Dec. 1970).

Key words: High-speed measurements; high temperatures; melting point; platinum.

A pulse heating method is described for the measurement of melting point of electrical conductors at high temperatures (above 2000 K) which are in the form of thin wires. The technique is checked by measuring the melting point of platinum. The results give 2044 ± 5 K on IPTS-1968.

A time-shared computer system for diffractometer control, H. A. Alperin and E. Prince, *J. Res. Nat. Bur. Stand. (U.S.),* **74C** (Eng. and Instr.), Nos. 3 and 4, 89-95 (July-Dec. 1970).

Key words: Automatic control; computer control; diffractometer; FORTRAN; neutron diffractometer; real-time data processing; time sharing; x-ray diffractometer.

A system is described for controlling data acquisition, and for online data reduction, on up to eight neutron and x-ray diffractometers. The system uses a medium-sized computer, with the individual instruments sharing time. Storage of programs, data, and the intermediate results of computations on a rapid-access disk makes roughly 12K of the 16K core memory available to each user in turn for computations. All users' programs are written in FORTRAN. Each user has independent access to the computer, through his own separate typewriter, for input of control parameters and output of sample results. Final output data may be recorded on magnetic tape for permanent filing or for processing offline by a large computer.

Tensile deformation of vapor-deposited copper reinforced with tungsten wires, W. D. Jenkins, W. A. Willard, and D. E. Harne, *J. Res. Nat. Bur. Stand. (U.S.),* **74C** (Eng. and Instr.), Nos. 3 and 4, 97-110 (July-Dec. 1970).

Key words: Composites; copper; electrical conductivity; fracture; law of mixtures; metallic bonding; tensile properties; tungsten; vapor-deposition; wires.

Short-time tensile tests were made at room temperature on sheet specimens of vapor-deposited copper containing zero to 26 volume percent continuous tungsten wires having diameters of 0.0005, 0.001, and 0.005-inch. Specimens were annealed at 25, 300, and 600 °C (298, 573, and 873 K) prior to testing. Strength, ductility, shape of the stress-strain curves, and types of fractures were influenced by volume fraction and number of layers of wires as well as by wire diameter and alinement. Strength values for the composites with 2 to 3 percent volume fractions of wires exceeded those predicted by the law of mixtures whereas at higher volume fractions, either conformance to the law was observed or lower values than those predicted were obtained. Increase in strength was accompanied by a decrease in electrical conductivity. All the properties investigated were markedly affected by increasing the annealing temperature. Tungsten wires failed in a ductile manner after considerable localized deformation ("necking") in various sections of the wires.

"Connector-pair" techniques for the accurate measurement of two-terminal low-value capacitances, A. Millea, *J. Res. Nat. Bur. Stand. (U.S.),* **74C** (Eng. and Instr.), Nos. 3 and 4, 111-116 (July-Dec. 1970).

Key words: Capacitance measurement; coaxial adaptor; coaxial connector; fringe capacitance; standard capacitor; two-terminal capacitor.

A method is described that allows two-terminal capacitance measurements to be performed with uncertainties of ± 0.0001 – 0.0002 pF, the ultimate accuracy limit being imposed only by the repeatability performance of the connectors. This technique has been used for the calibration of coaxial capacitance standards and the measurement of the fringe capacitance of coaxial open-circuit terminations; other applications are also possible in the field of high-frequency coaxial measurements.

The use of dew-point temperature in humidity calculations, L. A. Wood, *J. Res. Nat. Bur. Stand. (U.S.),* **74C** (Eng. and Instr.), Nos. 3 and 4, 117-122 (July-Dec. 1970).

Key words: Antoine Equation; dew point; humidity; hygrometry; psychrometric chart; relative humidity; vapor pressure of water; wet-bulb temperature.

The dew-point temperature has a number of desirable features as a means of expressing humidity. The Antoine Equation, $\log e_w = A - B(T+C)^{-1}$, where e_w is the partial pressure and T is the temperature of saturated aqueous vapor, represents the Goff-Gratch formulation quite well over the range of temperature from 0 to 140 °F. The pressure e_w, in inches of mercury, is obtained by taking the constants $A = 6.70282$, $B = 3150.515$ (°F)$^{-1}$ and $C = 391.0$ °F, calculated from values given by Dreisbach. It is shown that the dew-point DP is related to the relative humidity RH by the relation:

$$(DP+C)^{-1} = (T+C)^{-1} + B^{-1} \log (RH)^{-1}.$$

Lines of nearly constant positive slope represent constant relative humidity values on graphs of dew-point against temperature. The value of the slope decreases from unity for $RH = 100$ percent to about 0.76 for $RH = 10$ percent, corresponding to the linear equation

$$DP = [1 + 0.1471 \log (RH)^{-1}]^{-2} (T - 70) + DP_{70} \text{ where } DP_{70} = [2169 + 319 \log (RH)^{-1}]^{-1} \times 10^6 - 391.$$

Psychrometric charts showing dew-point and dry-bulb temperature as coordinates with lines representing constant relative humidity and constant wet-bulb temperature (obtained from the Ferrell Equation) are extremely useful, since given values for any two of these four variables serve to locate a point, from which the values of the other two variables can be read directly.

Bolovac application for hf and microwave power measurement and standardization, M. C. Selby, *J. Res. Nat. Bur. Stand. (U.S.)*, **74C** (Eng. and Instr.), Nos. 3 and 4, 123-133 (July-Dec. 1970).

Key words: Bolometric power standards; Bolovac power measurements; calibration of power meters; rf and microwave power measurements; standard of power through 18 GHz.

The bolometric voltage and current (BOLOVAC) standard for frequencies to 18 GHz and higher, recently developed at the National Bureau of Standards (NBS), can also be used to measure power, offering the following advantages over a number of other methods in use today: (1) It eliminates: (a) the uncertainty resulting from neglecting termination mismatch, (b) measurement of reflection coefficients and computations using complex equations, (c) "Limits-of-error" charts, thus rendering definitive results, (d) use of impedance charts, (e) dc or af calibrations of power meters, (f) need of corrections such as "effective efficiency" and "calibration factor." (2) It covers a wide frequency range (0.5 MHz to 18 GHz or wider); (3) It should result in substantial reduction of calibration time in many instances; (4) It can be applied to calibrate feed-through power measurement methods for power levels ranging into kilowatts.

In measuring power, the Bolovac (1) measures the voltage across a known resistance component of a given load, or (2) measures the voltage in any plane of a coaxial line of known characteristic impedance and known voltage distribution along the line, or (3) absorbs the rf power as any other absorption-type power mount does. In the first two cases resistance and voltage distribution measurements may be made separately or these measurements may be combined with the power measurement procedure. In the third case the rf power is absorbed in a special disk-type bolometric detector of the Bolovac and is equal to the dc- (or af) bias-power substituted in that detector; this bias power is measured with conventional power substitution bridges. Any appreciable unaccounted for power losses occur outside the Bolovac and can be determined employing conventional techniques as well as the Bolovac itself. The Bolovac needs no rf calibration. A Bolovac may have a power range of 20 dB or higher, depending on accuracy desired, and a maximum power approaching its safe power dissipation, e.g., 0.5 W or higher. This paper is limited to the application of the Bolovac to power measurements only and presents analytical and practical aspects of this application.

3.4. MONOGRAPHS

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

Monogr. 25, Section 8. **Standard x-ray diffraction powder patterns, Section 8.—Data for 81 substances,** H. E. Swanson, H. F. McMurdie, M. C. Morris, and E. H. Evans, Nat. Bur. Stand. (U.S.), Monogr. 25, Sec. 8, 171 pages (Sept. 1970).

Key words: Crystal structure; integrated intensities; lattice constants; peak intensities; powder patterns; reference intensities; standard; x-ray diffraction.

Standard x-ray diffraction patterns are presented for 81 substances. Fifty-three of these patterns represent experimental data and 28 are calculated. The experimental x-ray powder diffraction patterns were obtained with an x-ray diffractometer, using samples of high purity. All d-values were assigned Miller indices determined by comparison with computed interplanar spacings consistent with 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 computed from published crystal structure data. Both peak height and integrated intensities were reported for the calculated patterns.

Monogr. 113, Volume 1. **Research and development in the computer sciences. 1. Information acquisition, sensing, and input: A selective literature review,** M. E. Stevens, Nat. Bur. Stand. (U.S.), Monogr. 113, Vol. 1, 170 pages (Mar. 1970).

Key words: Audio inputs; automatic pattern recognition; character recognition; communication systems; data transmission; graphic inputs; image enhancement; remote sensing; source data automation; speech recognition.

This report, the first of a projected series on research and development efforts and requirements in the computer and information sciences, is concerned with a selective literature review involving the operations of information acquisition, sensing, and input to information processing systems considered in generalized terms. Specific topics include but are not limited to: source data automation and remote sensing techniques, communication systems and data transmission links, audio and graphic inputs, preprocessing operations upon input items such as image enhancement and property filtering, character recognition, speech recognition, and various other aspects of automatic pattern recognition. Supplemental notes and a bibliography of over 640 cited references are included.

Monogr. 113, Volume 2. **Research and development in the computer and information sciences. 2. Processing, storage, and output requirements in information processing systems: A selective literature review,** M. E. Stevens, Nat. Bur. Stand. (U.S.), Monogr. 113, Vol. 2, 125 pages (May 1970).

Key words: Computer-assisted-instruction; information display; information recording; machine-aided design; memory allocation; microforms; multiple-access systems; on-line systems; output modes; photocomposition and typesetting; storage hierarchies; time sharing.

Areas of concern with respect to processing, storage, and output requirements of a generalized information processing system are considered. Special emphasis is placed on multiple-access systems. Problems of system management and control are discussed, including hierarchies of storage levels. Facsimile, digital, and mass random access storage media and techniques are considered. A variety of output mode requirements are also considered, including direct recording to microforms; on-line display systems; printing, photocomposition, and automatic character generation; and three-dimensional, color, and other special-purpose display systems. Problems of system use and evaluation are also briefly noted. A bibliography of approximately 480 cited references is included, together with supplemental notes and quotations from the literature.

Monogr. 113, Volume 3. **Research and development in the computer and information sciences. 3. Overall system design considerations: A selective literature review,** M. E. Stevens, Nat. Bur. Stand. (U.S.), Monogr. 113, Vol. 3, 147 pages (June 1970).

Key words: Data recording; debugging; holography; information control; input-output; integrated circuits; lasers; memory systems; multiprocessing; networks; on-line systems; programming; simulation; storage.

This report, the third in a series on research and development efforts and requirements in the computer and information sciences, is concerned with a selective literature review involving overall system design considerations in the planning of information processing systems and networks. Specific topics include but are not limited to: requirements and resources analysis, problems of system networking, input/output and remote terminal design, character sets, programming problems and languages, processor design considerations, advanced hardware developments, debugging and on-line diagnosis or instrumentation, and problems of simulation. Supplemental notes and a bibliography of over 570 cited references are included.

Monogr. 114. **Survey of micromanometers,** W. G. Brombacher, Nat. Bur. Stand. (U.S.), Monogr. 114, 62 pages (June 1970).

Key words: Calibration techniques; capacitance pressure gages; gas column manometers; manometers; meteorographs; micromanometers; piston gages; pressure measurement; vane gages; vapor pressure measurement.

This survey is concerned with instrumentation for measuring pressures from about 0.001 to 50 mm of mercury (0.13 to 6650 Nm^{-2}), described in publications during the years 1900-1968. U-tube micromanometers and diaphragm-capacitance gages are treated in considerable detail. Other instrumentation described includes gas column manometers; elastic element micromanometers with optical, inductance, resistance wire, strain gage, and vacuum tube transducers; piston gages; vane gages; and centrifugal micromanometers. The measurement of dynamic pressure, atmospheric pressure oscillations, low vapor pressure, and calibration techniques are discussed. Only technical periodicals, books, and government or university laboratory serials were used as sources of information. Details of electrical measurement circuits, amplifiers, and recorders have been omitted. Schematic diagrams of approximately 70 instruments are included. References to the sources of information and available performance data are given.

Monogr. 115. **The calculation of rotational energy levels and rotational line intensities in diatomic molecules,** J. T. Hougen, Nat. Bur. Stand. (U.S.), Monogr. 115, 52 pages (June 1970).

Key words: Diatomic molecules; Hund's coupling cases; rotational levels; rotational line intensities; theoretical calculations.

Procedures are described, in this pedagogical monograph, for making quantum mechanical calculations of rotational energy levels and rotational line intensities in diatomic molecules. The procedures are illustrated by sample calculations. A familiarity with the material of this report should enable a practicing electronic spectroscopist to carry out, though in a rather mechanical way, his own theoretical calculations for molecules under experimental investigation. The material of this report is aimed at electronic spectroscopists who have had the equivalent of one semester of graduate-level quantum mechanics.

Monogr. 116. **Hydrogen Stark broadening calculations with the unified classical path theory,** C. R. Vidal, J. Cooper, and E. W. Smith, Nat. Bur. Stand. (U.S.), Monogr. 116, 143 pages (May 1970).

Key words: Classical path; hydrogen lines; line wings; one-electron theory; Stark broadening; unified theory.

The unified theory has been generalized for the case of upper and lower state interaction by introducing a more compact tetradic notation. The general result is then applied to the Stark broadening of hydrogen. The thermal average of the time development operator for upper and lower state interaction is presented. Except for the time ordering it contains the effect of finite interaction time between the radiator and perturbers to all orders, thus avoiding a Lewis type cutoff. A simple technique for evaluating the Fourier transform of the thermal average has been developed. The final calculations based on the unified theory and on the one-electron theory are compared with measurements in the high and low electron density regime. The unified theory calculations cover the entire line profile from the line center to the static wing and the simpler one-electron theory calculations provide the line intensities only in the line wings.

Monogr. 117. **Hearing aids,** E. L. R. Corliss, Nat. Bur. Stand. (U.S.), Monogr. 117, 26 pages (Oct. 1970).

Key words: Audition; communications; hearing; hearing aids; selection of hearing aids; speech communication.

This publication contains information, useful to the hard of hearing, on several topics relating to hearing and hearing aids. It is assumed that the individual has already consulted a physician on the diagnosis of his hearing loss, for this is the necessary first step in correcting any faulty hearing condition. The publication may also be of interest to teachers and others wishing to explore this field.

This publication represents an extensive revision of NBS Circular 534, Hearing Aids. It includes new material based upon research conducted at the National Bureau of Standards during the intervening years. (Supersedes Circular 534.)

Monogr. 118. **Photonuclear reactions,** E. Hayward, Nat. Bur. Stand. (U.S.), Monogr. 118, 46 pages (Aug. 1970).

Key words: Nuclear hydrodynamics; particle-hole calculations; photon scattering; photonuclear; sum rules.

This paper reviews photonuclear reactions in the approximate energy range 10 to 30 MeV. Various sum rules are discussed and applied to experimental data. Several different theories are described and their predictions compared with experiment, and as often as possible open questions and discrepancies are pointed out.

3.5. HANDBOOKS

Recommended codes of engineering and industrial practice (including safety codes) developed in cooperation with interested industries, professional organizations, and regulatory bodies. In many cases recommended requirements are given official status through their incorporation in local ordinances by State and municipal regulatory bodies.

H107. **American National Standard. Radiological safety in the design and operation of particle accelerators,** Nat. Bur. Stand. (U.S.), Handb. 107, 22 pages (June 1970).

Key words: Accelerator design; accelerator operation; health physics; particle accelerators; radiation measurements; radiation protection; standard.

This American National Standard provides the basic considerations essential to the safe operation of a particle accelerator. It applies principally to particle accelerators with primary energies less than 100 MeV. It considers the characteristics of and controls for radiations as they affect accelerator design, operating procedures, and exposure evaluation. The section on radiation protection design criteria includes radiation shielding considerations and the use of safety systems. Operational health physics requirements are treated extensively, and radiation measurements are discussed in terms of the types of radiation that may be produced and proper techniques for monitoring. The final section, on dose assessment, includes basic exposure considerations such as maximum permissible dose and dose equivalent.

3.6. SPECIAL PUBLICATIONS

This series 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, such as administrative pamphlets, wall charts and bibliographies.

SP236, 1970 Edition. **Services provided by NBS standard frequency and time stations. Radio stations WWV, WWVH, WWVB, and WWVL,** P. P. Viezbicke, Editor, Nat. Bur. Stand. (U.S.), Spec. Publ. 236, 1970 Edition, 16 pages (1970).

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

Detailed descriptions are given of the 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. In order to provide users with the best possible services, occasional changes in broadcasting schedules are required. This publication shows the schedules in effect on February 1, 1970. Annual revisions will be made. Current data relating to standard frequencies and time signals are available monthly in the Time and Frequency Services Bulletin. Advance notices of changes occurring between revisions will be sent to users of NBS broadcast services who request such notice on the basis of need. (Supersedes NBS Special Publication 236, 1969 and previous editions.)

SP260, 1970 Edition. **Catalog of standard reference materials,** Nat. Bur. Stand. (U.S.), Spec. Publ. 260, 1970 Edition, 84 pages (July 1970).

Key words: Analysis; characterization; composition; property of material; standard reference material; standards.

A descriptive listing of the various standard reference materials distributed at the present time by the National Bureau of Standards is given. These materials are used to calibrate measurement systems and to provide a central basis for uniformity and accuracy of measurement. The unit and quantity, the type, and the certified characterization are listed for each material, as well as directions for ordering. Announcements of new and renewal materials are made in the NBS Technical News Bulletin, and in scientific and trade journals. The current status and price will be indicated by insert sheets available at timely intervals from the Bureau. (Supersedes NBS Special Publication 260, 1969 Edition.)

SP260-17. **Standard reference materials: Boric acid; isotopic and assay; standard reference materials,** E. J. Catanzaro, C. E. Champion, E. L. Garner, G. Marinenko, K. M. Sappenfield, and W. R. Shields, Nat. Bur. Stand. (U.S.), Spec. Publ. 260-17, 70 pages (Feb. 1970).

Key words: Absolute ratios; assay standards; boron; coulometry; isotopic standards; mass spectrometry.

A precise coulometric titration method has been developed for the assay of boric acid. The method is capable of providing boric acid assays precise to within 0.0025 percent (1 sigma) which is an order of magnitude better than existing techniques. Using this method, a lot of high purity boric acid has been assayed and found to be virtually stoichiometric H_3BO_3. Its acidimetric assay value of 100.00 ± 0.01 percent characterizes this material as a primary chemical standard for boron determinations.

Multiple samples of boric acid were studied and characterized with respect to homogeneity and the effect of relative humidity on stoichiometry. Procedures for precise preparation, aliquoting and storage of boric acid solutions were devised.

A mass spectrometric technique for the precise measurement of boron isotope ratios was developed. Single-filament tantalum-ribbon sources are used, and $^{11}B/^{10}B$ ratios are determined by measuring the relative abundances of $Na_2{}^{11}BO_2{}^+$ and $Na_2{}^{10}BO_2{}^+$ ions, at masses 89 and 88, respectively. The effects of various parameters such as sample mounting procedure, filament material, sample size, total sample composition and sodium concentration were studied and alternative procedures were evaluated.

Absolute values were obtained for the isotopic abundance ratios of two boron isotopic standards, using surface emission mass spectrometry. Samples of known isotopic composition, prepared from nearly pure separated boron isotopes, were used to calibrate the mass spectrometers. The resulting absolute values are: SRM 951, Boric Acid, $^{11}B/^{10}B = 4.04362 \pm 0.00137$; and SRM 952, Boric Acid, $^{11}B/^{10}B = 0.053199 \pm 0.000032$. The indicated uncertainties are overall limits of error based on 95 percent confidence limits for the means and allowances for effects of known sources of possible systematic error.

SP260-19. **Analysis of interlaboratory measurements on the vapor pressure of gold (Certification of Standard Reference Material 745),** R. C. Paule and J. Mandel, Nat. Bur. Stand. (U.S.), Spec. Publ. 260-19, 21 pages (Jan. 1970).

Key words: Components of error (within- and between-laboratories); gold; heats of sublimation (second and third law); interlaboratory measurements; standard errors; standard reference materials; vapor pressure.

A detailed statistical analysis has been made of results obtained from a series of interlaboratory measurements on the vapor pressure of gold. The gold Standard Reference Material 745 which was used for the measurements has been certified over the pressure range 10^{-8} to 10^{-3} atm. The temperature range corresponding to these pressures is 1300-2100 K. The gold heat of sublimation at 298 K and the associated standard error were found to be 87,720 ± 210 cal/mol (367,040 ± 900 J/mol). Estimates of uncertainty have been calculated for the certified temperature-pressure values as well as for the uncertainties expected from a typical single laboratory's measurements. The statistical analysis has also been made for both the second and third law methods, and for the within- and between-laboratory components of error. Several notable differences in second and third law errors are observed.

SP260-23. **Viscosity of a standard borosilicate glass,** A. Napolitano and E. G. Hawkins, Nat. Bur. Stand. (U.S.), Spec. Publ. 260-23, 10 pages (Dec. 1970).

Key words: Beam-bending; borosilicate glass; glass viscosity; parallel-plate; rotating cylinder; standard reference material; viscosity; viscosity standard.

The viscosity of a borosilicate glass has been measured at the National Bureau of Standards and four other laboratories. Determinations were made in the range 10^2 to 10^{15} poises (1525 to 470 °C). Measurements were made by the rotating cylinder, fiber elongation, beam bending, and parallel-plate methods. The results have been evaluated and the glass has been issued as Standard Reference Material No. 717.

SP300. Volume 4. **Precision measurement and calibration. Electricity—radio frequency,** A. J. Estin, Editor, Nat. Bur. Stand. (U.S.), Spec. Publ. 300, Vol. 4, 456 pages (June 1970).

Key words: Admittance; antenna; attenuator; bolometer; calorimetry; horn; impedance; interferometry; measuring system; phase; power; radiometry; resonant cavity; voltage; waveform; waveguide junction.

This volume is one of an extended series which brings together some of the previously published papers, monographs, abstracts, and bibliographies by NBS authors dealing with the precision measurement of specific physical quantities and the calibration of the related metrology equipment. The contents have been selected as being useful to the standards laboratories of the United States in tracing to NBS standards the accuracies of measurement needed for research work, factory production, or field evaluation.

Volume 4 contains reprints through June 1967 on radiofrequency electrical measurements covering the following topics: Power, Sinusoidal Voltage and Current, Electromagnetic Fields and Antennas, Radar and Baseband Pulses, Noise, Attenuation and Phase, Impedance, Radio Frequency Materials, Quasi-optics and Millimeter Waves, and Applications to Measurement Systems.

SP300. Volume 6. **Precision measurement and calibration. Selected NBS papers on heat,** D. C. Ginnings, Editor, Nat. Bur. Stand. (U.S.), Spec. Publ. 300, Vol. 6, 387 pages (Feb. 1970).

Key words: Bomb calorimetry; calorimetric design principles; calorimetric methods; calorimetric theory; cryoscopic studies; differential thermal analysis; heat measurements; heat transfer; high temperature calorimetry; low temperature calorimetry; reaction calorimetry.

This volume is one of an extended series which brings together the previously published papers, monographs, abstracts, and bibliographies by NBS authors dealing with the precision measurement of specific physical quantities and the calibration of the related metrology equipment. The contents have been selected as being useful to the standards laboratories of the United States in tracing to NBS standards the accuracies of measurement needed for research work, factory production, or field evaluation.

Volume 6 contains reprints through 1968 covering the following topics: General Calorimetry and Techniques, Low Temperature Calorimetry, High Temperature Calorimetry, Reaction Calorimetry, and Heat Transfer.

SP315-4. **Bibliography on the high temperature chemistry and physics of materials, October, November, December 1969,** J. J. Diamond, Editor, Nat. Bur. Stand. (U.S.), Spec. Publ. 315-4, 85 pages (Jan. 1970).

Key words: Bibliography, high temperature; chemistry, high temperature; high temperature chemistry; materials properties; research at high temperatures; thermophysical properties.

The bibliography consists of references to research involving temperatures above 1000 °C, which were noted by the Contributors during the above three-month period. Since this is intended primarily as a current-awareness bibliography, there is no cross-referencing or indexing. This issue contains about 775 references roughly grouped under fifteen subject headings.

SP315-5. **Bibliography on the high temperature chemistry and physics of materials, January, February, March 1970,** J. J. Diamond, Editor, Nat. Bur. Stand. (U.S.), Spec. Publ. 315-5, 82 pages (Apr. 1970).

Key words: Bibliography, high temperature; chemistry, high temperature; high temperature chemistry; materials properties; research at high temperatures; thermophysical properties.

The bibliography consists of references to research involving temperatures above 1000 °C, which were noted by the Contributors during the above three-month period. Since this is intended primarily as a current-awareness bibliography, there is no cross-referencing or indexing. This issue contains about 750 references roughly grouped under fifteen subject headings.

SP319. **Man, his job, and the environment: A review and annotated bibliography of selected recent research on human performance,** W. G. Mather, III, B. V. Kit, G. A. Bloch, and M. F. Herman, Nat. Bur. Stand. (U.S.), Spec. Publ. 319, 107 pages (Oct. 1970).

Key words: Bibliography; effort; environment; fatigue; human performance; human physiology; psychology; psychophysics; stress (physiological); stress (psychological) work.

Recent scientific literature was searched to review procedures currently being used to study human reactions to work and environmental stress. An ecological context is followed, considering task variables, environmental conditions, individual variations in subjects, and physiological, psychophysical, psychological, and sociological responses. The different types of research reviewed included analyses of on-the-job performance, simulations of real-life situations, laboratory experiments with human and nonhuman subjects, and clinical studies. A methodological program is suggested for measuring the expenditure of effort in work situations. In addition to an extensive bibliography, detailed abstracts of 190 research reports are presented.

SP320. **Bibliography on atomic transition probabilities, January 1916 through June 1969,** B. M. Miles and W. L. Wiese, Nat. Bur. Stand. (U.S.), Spec. Publ. 320, 111 pages (Feb. 1970).

Key words: Atomic; discrete; forbidden; permitted; transition probability.

A revised and updated bibliography on atomic transition probabilities including all new references up to July 1, 1969 is presented. The papers, except for a number of comprehensive articles, are arranged according to elements and stages of ionization. In addition to the literature reference the employed experimental or theoretical method is indicated. For the 20 lightest elements and Ba I and II the literature is presented on a critically selected basis. To keep the bibliography to a compact size, a number of comprehensive papers which contain numerical results throughout extended isoelectronic sequences are listed in a separate section. Also included in this bibliography is a supplementary list of selected important papers dealing with the subject of transition probabilities from a general point of view.

SP321. **An author and permuted title index to selected statistical journals,** B. L. Joiner, N. F. Laubscher, E. S. Brown, and B. Levy, Nat. Bur. Stand. (U.S.), Spec. Publ. 321, 510 pages (Sept. 1970).

Key words: Bibliography; computer indexing; index; key word in context; KWIC; permuted title index; statistics.

Over 5,000 articles appearing in the indicated issues of the following journals are indexed: *Annals of Mathematical Statistics* (1961-1969), *Biometrics* (1965-1969 #3), *Biometrike* (1951-1969), *Journal of the American Statistical Association* (1956-1969), *Journal of the Royal Statistical Society, Series B* (1954-1969 #2), *South African Statistical Journal* (1967-1969 #2), *Technometrics* (1959-1969). The articles indexed correspond to those appearing since the most recent cumulative subject index was published for the first six named journals, while for *Technometrics* all articles have been included even though a subject index exists for the first seven volumes. The index consists of three sections, an author index, a permuted title index and a bibliographic listing. In the permuted title index each article is listed under every important word appearing in its title. This index should consequently serve many of the functions of a conventional subject index. The author index is similar to a conventional author index.

SP322. **Photonuclear data index, Supplement 2 (1970),** Nat. Bur. Stand. (U.S.), Spec. Publ. 322, 86 pages (May 1970).

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 January, 1970. Organized by element and isotope, each entry in the index is for a specific reaction reported in a given reference. Information is given on the type of measurement, excitation energies studied, source type and energies, detector type and angular ranges covered in the measurement. (Supersedes Supplement 1 to Miscellaneous Publication 277.)

SP325. **Technical highlights of the National Bureau of Standards, Annual Report Fiscal Year 1969,** Nat. Bur. Stand. (U.S.), Spec. Publ. 325, 243 pages (Mar. 1970).

Key words: Annual report; technical highlights.

This is an illustrated digest of NBS technical and scientific activities during the fiscal year ending June 30, 1969. It lists major programs as they were carried out by the three NBS institutes: Institute for Basic Standards, Institute for Materials Research, Institute for Applied Technology and by the Bureau's Center for Radiation Research and Center for Computer Science and Technology. Summaries are given of typical projects in measurement engineering, applied mathematics, electricity, metrology, mechanics, heat, atomic physics, radio standards, laboratory astrophysics, cryogenics, analytical chemistry, polymers, metallurgy, inorganic materials, physical chemistry, engineering standards, weights and measures, invention and innovation, vehicle systems research, product evaluation, building research, electronic technology, technical analysis, computer sciences, and radiation research. Also included are discussions of the Clearinghouse for Federal Scientific and Technical Information, the National Standard Reference Data System, Standard Reference Materials program, and national and international cooperative activities.

SP327. **Equilibrium critical phenomena in fluids and mixtures: A comprehensive bibliography with key-word descriptors,** S. Michaels, M. S. Green, and S. Y. Larsen, Nat. Bur. Stand. (U.S.), Spec. Publ. 327, 235 pages (June 1970).

Key words: Binary liquid mixtures; critical opalescence; critical phenomena; critical point; critical region; equilibrium critical phenomena; gases; liquids; liquid-vapor systems; phase transitions; ternary liquid mixtures; thermodynamics.

This bibliography of 1088 citations comprehensively covers relevant research conducted throughout the world between January 1, 1950 through December 31, 1967. Each entry is characterized by specific key word descriptors, of which there are approximately 1500, and is indexed both by subject and by author. In the case of foreign language publications, effort was made to find translations which are also cited.

SP331. **Radioactivity calibration standards.** Proceedings of a special session of the International Conference of the American Nuclear Society Meeting on the Constructive Uses of Atomic Energy, Washington, D.C., November 10-15, 1968, W. B. Mann and S. B. Garfinkel, Editors, Nat. Bur. Stand. (U.S.), Spec. Publ. 331, 120 pages (Aug. 1970).

Key words: Alpha-particle standards; calibration consistency; coincidence counting; decay-scheme effects; efficiency tracing; gamma-ray standards; international comparisons; liquid-scintillation counting; radionuclide half-lives; radionuclide standards.

Experimental procedures and methods used in nine international radioactivity standardization laboratories are described by eight authors. The possibility of attaining accuracies of the orde1 of 0.01% are discussed. The desirability of carrying out consistency checks of gamma-ray standards with time, using a $4\pi\gamma$ ionization chamber is emphasized. The validity of radioactivity standards is examined. International comparisons organized by the Bureau International des Poids et Mesures are discussed. An analogue method of liquid-scintillation counting is described. Certain types of radioactivity standards are criticized. The fields of interest of the two Canadian laboratories are discussed. Details of the work in progress at the Boris Kidrič Institute and National Bureau of Standards are presented. *These proceedings include the following papers (indented)*:

Aspects of radionuclide standardization in the IAEA, H. Houtermans, *SP331*, pp. 5-12 (Aug. 1970).

Some aspects of radioactivity standardization at the CBNM of Euratom, A. Spernol, *SP331*, pp. 13-24 (Aug. 1970).

International comparisons of calibrated radionuclide sources, A. Rytz, *SP331*, pp. 25-36 (Aug. 1970).

Standardization of radionuclides by efficiency-tracing methods using a liquid-scintillation counter, D. G. Jones and A. McNair, *SP331*, pp. 37-52 (Aug. 1970).

Validity of radioactive standards, Y. Le Gallic, *SP331*, pp. 53-68 (Aug. 1970).

Radioactivity standardization in Canada, J. G. V. Taylor and A. P. Baerg, *SP331*, pp. 69-77 (Aug. 1970).

Metrology of radioactive isotopes at the Boris Kidrič Institute of Nuclear Sciences at Vinča-Beograd, Yugoslavia, Dj. N. Bek-Uzarov, *SP331*, pp. 79-103 (Aug. 1970).

Recent activities of the NBS Radioactivity Section, with special reference to the standardization of thallium-208, S. B. Garfinkel and J. M. R. Hutchinson, *SP331*, pp. 105-118 (Aug. 1970).

SP332. **Spectrum formation in stars with steady-state extended atmospheres.** Proceedings of the International Astronomical Union Colloquim No. 2, Commission 36, Munich, Germany, April 16-19, 1969, H. G. Groth and P. Wellmann, Editors, Nat. Bur. Stand. (U.S.), Spec. Publ. 332, 342 pages (Aug. 1970).

Key words: Chromospheres; coronae; extended atmospheres; non-classical atmospheres; non-LTE.

Commission 36 of the International Astronomical Union sponsored a symposium on Spectrum Formation in Extended Stellar Atmospheres held 16-19 April, 1969. The host was the Observatory of the University of Munich. A major problem is the definition of what is meant by an extended stellar atmosphere. There are intuitive notions in the literature, but the question of specific definitions in various kinds of objects was discussed. Questions of what specifically cause the anomalous extent were largely by-passed. Attention focused mainly on the type spectrum to be expected in various situations. The spectral features to be expected in both static and dynamic atmospheres, including and excluding departures from LTE, were discussed. The symposium was divided into four sections: A. Type of

Problems Which Exist; B. Theoretical Methods for Handling Non-LTE Problems; C. Chromospheres and Coronae of Stars; D. Summary. This volume contains the mms of the formal papers that were presented plus an edited and abridged version of the discussions following each paper. *These proceedings include the following papers (indented)*:

Definition of the types of problems that exist in steady-state extended atmospheres, A. B. Underhill, *SP332*, pp. 3-37 (Aug. 1970).

Key words: Extended atmospheres; interpretation of stellar spectra; line formation.

In section 1 practical details concerning the equivalence of observational and theoretical descriptions of stellar spectra are reviewed, particularly the difficulty of identifying the observed reference level (continuum) with the theoretical continuum in the case when many lines are present. In this connection thought must be given to how integrals over frequency should be normalised and evaluated because the effective continuous absorption coefficient does not remain constant over the range from 0 to ∞. The choice of spectroscopic details by which to determine T_{eff}, log g and abundances requires careful consideration.

In section 2 the factors by which an extended atmosphere are recognized are summarized and the question is posed do all stars have extended atmospheres. Another question requiring an answer is whether the concepts microturbulence and macroturbulence are physically real concepts or whether they are merely fitting parameters to make a simple LTE theory account for the observed spectra of supergiants in which rather wide lines occur and many multiplets show rather steep gradients. In section 3 the types of line sensitive to non-LTE conditions are described. These are resonance lines, lines arising from metastable levels, subordinate lines for which the upper level is sufficiently separated from the continuum and other levels that this upper level is chiefly populated by radiative processes from the ground or other low lying levels and lines which go into emission in low density atmospheres as a result of optical-pumping (fluorescent) processes. Such lines should not be used for abundance determinations by means of LTE theory though this is frequently done.

Theoretical considerations are discussed in Section 4 where first the problem of the two-level atom is sketched and then the problem is generalised to a many-level atom. The parameter λ which gives the probability that a photon is lost from the line by de-excitation processes other than spontaneous emission is defined and it is pointed out that non-LTE physics has the effect of adding a scattering term to the expression for the source function. One example is given of the effect of changing the line source function from the Planck function to a form suitable for isotropic coherent scattering. The line becomes deeper and wider for the same number of atoms. Interpretational problems in stellar spectra are discussed in section 5. It is noted that many lines in main-sequence early type spectra show the effects of departures from LTE. These effects are shown to a conspicuous degree by the spectra of shell stars. The example of He I 5876 in 10 Lacertae, 09V, is discussed and the implication for interpreting the He I lines in all B type main-sequence stars are touched upon. Helium-weak and helium-strong spectra probably indicate variations in density of the outer atmosphere rather than true abundance differences. The spectra of supergiants are also considered and it is pointed out that the Ia supergiants of type B may be hydrogen-poor.

Finally in section 6 the problem of choosing simplified physical representations of line forming when non-LTE physics must be used is discussed. Some relevant points concerning the observed spectral lines used for spectral classification are illustrated by means of partial energy-level diagrams.

Definition of the physical problems connected with extended atmospheres, R. N. Thomas, *SP332*, pp. 38-53 (Aug. 1970).

Key words: Classical atmosphere model; extended stellar atmosphere.

The necessity of carefully defining the phenomenological basis for classification of atmospheres as being "extended" is emphasized, and four alternative bases for such classification are suggested (1) the necessity to include curvature terms; (2) the presence of an ejected shell surrounding a central star; (3) an observational discrepancy between predicted and observed density gradient; (4) an anomaly between predicted and observed phenomena in stars with "dynamic" atmospheres such as cepheids. A number of physical problems connected with the presence of an extended stellar atmosphere are then categorized according to these alternative bases.

Extended atmospheres of planetary nuclei, K. H. Böhm and J. Cassinelli, *SP332*, pp. 54-60 (Aug. 1970).

Key words: Central stars of planetary nebulae; instability limit; nongray; Wolf-Rayet nuclei.

Exploratory calculations on nongray, hydrostatic-equilibrium model envelopes for central stars of planetary nebulae of high temperature and possibly near the instability limit are reported. It is conjectured that these may be related to Wolf-Rayet type nuclei; it appears possible to obtain an OV absorption, and OVI emission, spectrum even in an LTE calculation.

The N IV λ5820 multiplet in WN stars, H. Nussbaumer, *SP332*, pp. 61-64 (Aug. 1970).

Key words: HD 192163 WN6; N IV transition probabilities.

Evaluating transition probabilities of N IV 2p3d $^3P^0$ to 2s4s ^3S and 2p3p ^3P and an emission feature at λ7410 it is shown that a disputed emission at λ5810 in WN stars may not be attributed to N IV.

A self-consistent model atmosphere program with applications to solar 0I resonance lines, R. G. Athay and R. C. Canfield, *SP332*, pp. 65-84 (Aug. 1970).

Key words: Non-LTE line formation; resonance lines; solar UV lines.

Profiles and total intensities are computed for solar 0I resonance lines at λ1302 and λ1305 using a model atmosphere program that includes non-LTE effects in both hydrogen and oxygen and that includes microturbulence both as a line broadening mechanism and as a contribution to the gas pressure. Good agreement is obtained between computed and observed intensities. The computed profiles appear to have too much self-reversal.

Theoretical methods of treating line formation problems in steady-state extended atmospheres, G. B. Rybicki, *SP332*, pp. 87-118 (Aug. 1970).

Key words: Moving atmospheres; radiative transfer; spectral line formation; spherical geometry; stellar atmospheres.

Theoretical methods applicable to the study of line formation in steady-state extended atmospheres are reviewed.

The formal solution of the transfer equation is considered, as well as numerical and analytical methods of determining the source function. Topics discussed include: the local frequency transformation, geometrical effects, and the case of large velocity gradients. A new plane-parallel approximation for spherically symmetric moving atmospheres is given that takes account of transverse velocity gradients.

Application of Monte Carlo methods in transfer problems, C. Magnan, *SP332*, p. 119 (Aug. 1970).

Line formation in moving atmospheres, W. Kalkofen, *SP332*, pp. 120-133 (Aug. 1970).

Key words: Line formation: line-profile computation; moving atmospheres.

We discuss an integral equation method that permits the calculation of the line source functions and of the emergent profiles in finite and semi-infinite atmospheres with macroscopic motion normal to the surface. Solutions are presented for a semi-infinite atmosphere with a temperature rise in the outward direction and with a flow that decays with increasing depth. The computed profiles have the form of P Cygni lines.

Laser action in non-LTE atmospheres, D. H. Menzel, *SP332*, pp. 134-137 (Aug. 1970).

Key words: Laser action; radiative transfer.

The radiative transfer equation is written in microscopic form, and from some simplifications on the ratio of occupation numbers for upper and lower level, a laser action is suggested.

Line formation in multi-dimensional media, H. P. Jones and A. Skumanich, *SP332*, pp. 138-170 (Aug. 1970).

Key words: Line formation in multi-dimensional media; matrix methods for integro-differential operators; numerical methods in transfer; radiative transfer in inhomogeneous media.

The flux divergence technique of Athay and Skumanich (1967) is generalized for application to media whose properties vary in more than one spatial dimension. In this method, the flux divergence is viewed as an integro-differential functional of the source function. The source function is then expanded in terms of basis functions along characteristic paths, and, with the help of various interpolations, the flux divergence is converted to an approximate linear algebraic operator on a discrete spatial grid. A large but finite set of linear, inhomogeneous, simultaneous algebraic equations with known matrix coefficients is thus generated and is solved by direct matrix inversion for the source function at each point of the spatial grid.

Some aspects of the accuracy, stability, and computational convenience of the technique are discussed. Sample solutions for depth dependent, axially symmetric variations of temperature are shown.

The continuous spectrum of hydrogen in a low-density envelope, H. Gerola and N. Panagia, *SP332*, pp. 171-178 (Aug. 1970).

Key words: Collisional excitation; low-density envelope; recombination case.

A progress report on theoretical work on the formation of a continuum in low-density stellar envelopes. Preliminary results are given on a comparison between the recombination case and the case for a semi-empirical approach including the effect of collisions from the ground state.

Bandwidth requirements in spectral line transfer calculations, R. G. Athay, *SP332*, pp. 179-188 (Aug. 1970).

Key words: Bandwidth requirements; line source function.

Accurate evaluation of a line source function, S, requires that the frequency bandwidth be sufficiently large to include properly transfer effects in the line wings. The bandwidth required to achieve a given level of accuracy in the evaluation of S can be specified, in units of the Doppler width, in terms of three parameters: the ratio of continuum to line opacity, r_o, the probability for collisional de-excitation, ϵ, and the Voigt wing parameter a. Bandwidths required to give S to an accuracy of 2 percent are given for values of ϵ and r_o from 10^{-2} to 10^{-8} and for values of a from 10^{-2} to 10^{-5}.

Comparison of discrete space and differential equation methods in non-LTE line transfer problems, P. P. Grant and G. E. Hunt, *SP332*, pp. 189-225 (Aug. 1970).

Key words: Inhomogeneous non-LTE atmospheres; line formation; numerical methods.

Numerical methods are essential to the treatment of line formation in inhomogeneous non-LTE atmospheres. The new methods due to Hummer and Rybicki and to Feautrier now make it possible to make such calculations, although these are often quite time-consuming.

We shall describe an alternative approach using discrete space techniques depending on concepts of invariance. The solution algorithm is closely related to the method of Hummer and Rybicki, whose equations are obtained as a limiting case. The stability and errors of our algorithm are susceptible to mathematical analysis, and make it possible to identify the critical parameters in the calculation with precision. The results for a two-level problem will be compared with those from an implementation of the Rybicki-Hummer equations and a comparison will be made of the performance of the two procedures in respect of speed of computation and storage requirements.

Coherent line formation with depth-dependent parameters, T. R. Carson, *SP332*, pp. 226-238 (Aug. 1970).

Key words: Coherent line formation; numerical methods.

A discrete ordinate method is developed for solving the equation of coherent line formation, for arbitrary given variations with depth in an atmosphere of the temperature (or Planck function, assuming local thermodynamic equilibrium) and the line absorption and scattering coefficients. The direct solution thus obtained can then be used as the starting point of an iterative procedure. Results obtained for an exactly soluble case indicate the utility of the method.

What do we know through spectral information on stellar chromospheres and coronas?, F. Praderie, *SP332*, pp. 241-258 (Aug. 1970).

Key words: Chromosphere; conservation equations; corona; spectral indicators.

Four problems in interpreting spectra to infer chromospheres-coronas are summarized. (1) The *a priori* difficulties in interpreting spectra lie in uncertainty on the range of possible models, coming from uncertainty as to which conservation equations may be applied, and from lack of an exhaustive list of spectral indicators that may be used for uniqueness tests. (2) As spectral indicators we consider: emission lines, self-reversed emission cores, the presence of He I lines in stars not of early type, coronal-type high ionization, excess continuum emission in the rocket UV and the far infrared. (3) To determine what we can infer from observations, we summarize information: inferred by comparison of models to data, on velocity fields, and on spectral variability which might suggest chromospheric activity. (4) We summarize the evidence for chromospheres in A stars, as being those where convection-induced acoustic heating is marginal.

What should we do to know more about chromospheres and coronae of stars?, R. N. Thomas, *SP332*, pp. 259-282 (Aug. 1970).

Key words: Chromospheres; classical atmosphere model; coronas.

Chromospheres-coronas satisfy the last two of the proposed classification schemes: inadequacy of the classical atmosphere (CA) model to represent observations and a priori rejection of the CA model. So we survey the question of what is required for more knowledge from the standpoint of asking what conceptual modifications will increase knowledge and what new observations are required. We stress that continued progress requires a continual interchange of ideas between the solar situation and the range of stellar situations.

Observations of ζ aurigae stars and their interpretation, H. G. Groth, *SP332*, pp. 283-289 (Aug. 1970).

Key words: Chromosphere; chromospheric clouds; Russell-Adams effect; super-excitation.

A summary of information on the extended atmosphere of the K component coming from three eclipsing binaries consisting of a K supergiant and a main sequence B star. Various anomalies exist: (1) Discrepancy between electron density and metallic density inferred from observations, noting that the electrons should come from the metals. This suggests a cloud structure in the atmosphere. (2) Anomalous excitation temperatures and populations of the second quantum level of hydrogen suggests a solar-chromosphere type behavior for these K atmospheres. (3) Significant changes in the profiles of the Ca^+ lines from one eclipse to another. The necessity to distinguish between effects coming from radiation of the B star on the K atmosphere and chromospheric-like effects is emphasized.

Ionization in nova atmospheres, P. Wellmann, *SP332*, pp. 290-294 (Aug. 1970).

Key words: Expansion; ionization; novae shell.

Calculations on the expansion of novae shells are presented, from which the degree of ionization is obtained using a simplified form of a non-LTE ionization equation. From this, estimates of the time of vanishing of the Balmer absorption spectrum can be made.

Circumstellar Ca II K lines in G, K, and M giants and supergiants, A. H. Vaughan, Jr., and A. Skumanich, *SP332*, pp. 295-299 (Aug. 1970).

Key words: Ca^+ emission core; circumstellar absorption lines; late-type giants.

Tentative evidence based on photoelectric observations of the Ca^+ emission core, is presented for the existence of circumstellar envelopes in several G and K type "giants." A significant emission asymmetry in α Tau may imply a chromospheric rather than a circumstellar source.

A physical mechanism for the generation of extended stellar atmospheres, R. W. Hillendahl, *SP332*, pp. 300-319 (Aug. 1970).

Key words: Cepheids; extended atmospheres; hydrodynamics; shock waves.

A physical mechanism that can result in the generation of extended expanding atmospheres is discussed. The process involves the unloading of stellar material following the arrival of a shock wave at the edge of the star. The basic principles are developed from a discussion of a simplified case that has been studied in the laboratory; they are then applied to the atmosphere of a star. A radiation-hydrodynamics computation of a model cepheid is then used to obtain quantitative atmospheric profiles. The computed continuum and spectral lines during the unloading process are then examined. A discussion of the possibility that the unloading process occurs in stars other than cepheids suggests the existence of a shock visibility factor associated with ionization or dissociation in the region behind the shock front and leads to a possible alternate interpretation of the variable star instability strips in the H-R diagram.

SP333. **Research materials developed under the NBS inorganic materials program,** F. E. Brinckman and J. B. Wachtman, Jr., Nat. Bur. Stand. (U.S.), Spec. Publ. 333, 71 pages (September 1970).

Key words: Chemical properties; composition; gases; glasses; liquids; multiphase materials; physical properties; polycrystals; preparation; research.

The National Bureau of Standards develops many specialized materials in the process of carrying out research supporting its measurements, standards, and service activities. These materials include gases, liquids, glasses, single crystals, polycrystals, and various multiphases materials; their compositions (including trace elements in some cases) and physical characteristics are tailored to specific research needs, but the materials are often of use for other research purposes. Production is usually limited to immediate internal needs and samples are not generally available for distribution, but knowledge of production techniques and materials characteristics which may be helpful to other scientists is available. The present listing of research materials developed in the Inorganic Materials Division accordingly gives names of scientific staff members who may be contacted for this type of information as well as giving a brief summary of the nature, method of preparation and properties determined for each material.

SP338. **Status of thermal analysis.** Proceedings of a Symposium on the Current Status of Thermal Analysis held at Gaithersburg, Maryland, April 21-22, 1970, O. Menis, Editor, Nat. Bur. Stand. (U.S.), Spec. Publ. 338, 189 pages (Oct. 1970).

Key words: Atherosclerotic plaque; DSC; elastomers and vulcanizates; explosives; high temperature DTA; kinetics by TGA; selection of DTA parameters; temperature standards; TGA; theory of isoperibol and adiabatic shield calorimeters.

The symposium papers offer contributions in differential thermal analysis (DTA), differential scanning calorimetry (DSC), development of standards for DTA temperature scales, and applications in high temperature biochemical, polymer and explosive materials. The selection and the effect of experimental parameters on the types of information on thermal curves is described. The measurement theory of isoperibol and adiabatic shield calorimeters by the method of intermittent heating is described and the magnitude of calorimetric instrumental errors is outlined. In an analysis of a differential scanning calorimeter, three instrumental time constants are described and the necessary corrections for the various instrumental and thermal time constants are recommended. The need for and the status of temperature scale standards for DTA is discussed. An evaluation of 12 materials for use as standards by cooperating laboratories is presented. High temperature (> 1900 K) DTA, problems of high temperature calorimetry to 1300 K are discussed. The implications concerning the nature of biological membranes and decomposition of atherosclerotic plaques are derived from differential scanning calorimetry of three-component systems of phospholipid, cholesterol or one of its esters and water.

A description is given of an apparatus developed for measuring the rate at which vapors are evolved during the thermal degradation of material in a modified thermogravimetric apparatus. The modifications of a DTA cell to minimize explosions is described. Data derived from the use of lead azide was used to evaluate the technique. Thermogravimetric analysis for establishing basic composition of elastomer compounds and vulcanizates were reviewed. A careful study of oxidation characteristics of carbon black in the formulation is also included. *These proceedings include the following papers (indented):*

Standardization of differential thermal analysis test methods, P. D. Garn, *SP338,* pp. 1-22 (Oct. 1970).

Key words: DTA atmosphere effects; DTA experimental design; DTA peak structure; DTA sample shapes; DTA standardization.

The appearance of a differential thermal analysis curve depends greatly, for many materials, upon the method of experimentation. This is because the physical properties of the specimen will have differing effects upon the actual events taking place. The experimental parameters, mainly the sample holder and atmosphere, should be selected to learn as much as possible about the properties of most interest. The use of a single set of conditions as a general practice will be ineffective.

Macrocalorimetry—how accurate?, K. L. Churney, G. T. Armstrong, E. D. West, *SP338,* pp. 23-59 (Oct. 1970).

Key words: Adiabatic shield; calorimetric errors; calorimetry; isoperibol; measurement theory.

The measurement theory of isoperibol and adiabatic shield calorimeters operated by the method of intermittent heating is reviewed and recent developments indicated. Implications of the theory in terms of calorimeter design and tests for systematic errors are discussed. Some idea of the magnitude of calorimetric errors (as compared to errors arising from uncertainties in the change of state of the system under study) is outlined.

Status of thermal analysis temperature scale standards, O. Menis and J. T. Sterling, *SP338,* pp. 61-86 (Oct. 1970).

Key words: ASTM Committee; differential thermal analysis; International Committee on Thermal Analysis; temperature scale region of 40 to 900 °C; temperature scale standards.

Current status in the development of suitable temperature scale standards for differential thermal analysis is described. It involved the cooperative effort at NBS in the collection and evaluation of data on 12 materials studied by the Standards Committee of the International Committee on Thermal Analysis. In addition the results of the study group of an ASTM Committee with the cooperation of NBS are presented. The selected temperature values depend on the transition temperature of a number of compounds as well as two low temperature melting metals. The temperature scale region of 40 to 900 °C can be covered effectively with the ten materials, which will serve as calibration standards.

High temperature differential thermal analysis, R. D. Freeman, *SP338,* pp. 87-98 (Oct. 1970).

Key words: Differential thermal analysis; dynamic calorimetry; high temperature chemistry.

Three areas are discussed: (1) high temperature (> 1900 K) differential thermal analysis (DTA); (2) some problems in conventional high temperature calorimetry, which may be relevant to high temperature dynamic calorimetry; and (3) a brief description of our efforts to achieve dynamic calorimetry to at least 1300 K.

Thermal studies on lipid-water systems by differential scanning calorimetry with reference to atherosclerosis, G. J. Davis and R. S. Porter, *SP338,* pp. 99-117 (Oct. 1970).

Key words: Atherosclerosis; cholesterol and its fatty acid esters; differential scanning calorimetry; lecithin; lipid-water systems; phospholipids; sphingomyelin; thermal studies.

Studies have been performed on lipid-water systems by differential scanning calorimetry. Three-component systems were investigated. The components consisted of a phospholipid, cholesterol or one of its esters, and water. The phospholipids studied included lecithin and sphingomyelin. The cholesteryl derivatives used in the ternary systems included cholesterol and its oleate, linoleate, and stearate esters. The temperatures and heats of transition for these systems were investigated. The results reveal considerable differences in the stability of complexes formed in these ternary systems with the unsaturated esters generally leading to the least stable structures. The morphologies likely represent compositions and order similar to the layered structures observed for the same and related phospholipid-cholesteryl derivative molecular organization. The results have implications concerning the nature of biological membranes and the deposition of atherosclerotic plaques.

An analytical evaluation of differential scanning calorimetry (DSC), J. H. Flynn, *SP338,* pp. 119-136 (Oct. 1970).

Key words: Analyses of thermal apparatus; differential scanning calorimetry; evaluation of heats and temperatures of transition; instrumental time constants; interfacial thermal conductivity; thermal analyses.

Three instrumental time constants were found in an analysis of the (Perkin-Elmer DSC-1B) Differential Scanning Calorimeter: an energy pulse response (1.5 s), a temperature-averaging network response (≈ 15 s) and a temperature programming response (8.0 s). The first constant may be determined from the decay of the response to infrared light pulses. It affects the shape of a transition curve but not the heat of transition calculated from the area. The second constant affects only the base line and the third, the temperature calibration.

Application of elementary heat flow theory to a wide range of experimental variations in the interfacial thermal resistance demonstrated that interfacial time constants are a negligible factor in determining the melting transitions of many substances.

It was concluded that corrections for the various instrumental and thermal time constants are necessary if meaningful parameters are to be deduced, especially at fast heating rates.

Apparatus for rate studies of vapor producing reactions, R. J. McCarter, *SP338*, pp. 137-150 (Oct. 1970).

Key words: Differential thermal analysis; DTA; kinetics; pyrolysis; TGA; thermal analysis; thermal degradation; thermogravimetric analysis.

An apparatus was developed for measuring the rate at which vapors are evolved during the thermal degradation of materials and thereby deriving the kinetics of such reactions. Requisite to the operating scheme of the apparatus is the provision of a high-temperature zone to convert condensable or tarry vapors into noncondensable form.

The apparatus yields a direct measure of reaction velocity, rather than the integrated indication obtained with thermogravimetric analysis. This simplifies the identification and calculation of kinetic parameters. Increases in sensitivity and operating range are also achieved. Flexibility in operation is obtained that permits the separate recording of reactions that tend to overlap.

Although the apparatus has been operated principally with a combustible gas indicator serving to meter the evolved product vapors, a number of options are available for the latter function, including flow meters and various continuous gas analyzers. The applicability of the method appears promising.

Differential thermal analysis of primary explosives—a modified technique, R. J. Graybush, F. G. May, A. C. Forsyth, *SP338*, pp. 151-164 (Oct. 1970).

Key words: Differential thermal analysis; Dupont 900 DTA remote cell; lead azide; lead styphnate; mercury fulminate; metastable materials; potassium dinitrobenzfuroxan; primary explosives.

The usefulness of differential thermal analysis (DTA) in the study of metastable materials has been hindered by the tendency of samples to explode during the experiment. A description is given of modifications which have been made to the remote cell used in conjunction with a Dupont 900 DTA such that the possibility of explosion is minimized. Using lead azide to evaluate the technique it is shown that complete curves for the exothermic decomposition

$$PbN_6 \rightarrow Pb + 3N_2$$

are reproducibly obtained. The endotherm in the curve corresponding to the fusion of the product lead serves as a confirmation of the reaction. Illustrations are given to show extensions of the system to other sensitive compounds, namely lead styphnate, mercury fulminate, and potassium dinitrobenzfuroxan.

Thermogravimetry of vulcanizates, J. J. Maurer, *SP338*, pp. 165-185 (Oct. 1970).

Key words: Carbon black; curatives; elastomer compounds and vulcanizates; oxidation; thermogravimetric analysis.

Thermogravimetric analysis provides an important advance in the analysis of elastomer compounds and vulcanizates. This paper reviews the current state of such investigations including a consideration of key experimental variables, precision and accuracy for estimating basic composition of different types of practical formulations. Additional information can be obtained by careful study of the oxidation characteristics of the carbon black in the formulation. The latter is influenced by both physical (e.g., surface area) and chemical (type of cure system or polymer) effects. Finally, an isothermal oxidation procedure is discussed for demonstrating differences in carbon black(s) and/or curatives in routine comparisons of samples.

SP345-1. **International Standards. U.S. Metric Study Report,** Nat. Bur. Stand. (U.S.), Spec. Publ. 345-1, 157 pages (Dec. 1970).

Key words: Engineering standards; IEC; ISO; International standardization; metric study; PL 90-472; product certification; standards; U.S. Metric Study.

This report discusses developments on the international scene that have occurred since the passage in 1968 of the Metric Study Act, PL 90-472. Australia, Canada and other countries of the British Commonwealth have recently taken steps toward the adoption of the metric system for their customary weights and measures. European countries are harmonizing their national standards and are developing international agreements for quality assurance and product certification. These harmonized standards are being based on recommendations issued by the International Electrotechnical Commission (IEC) and the International Organization for Standardization (ISO).

The issue of international standardization is separate and distinct from those of the Metric Study, but the two subjects overlap somewhat, particularly in the case of dimensional standards. The extent to which U.S. standards are adopted by IEC and ISO depends mostly on U.S. participation in committees or groups drafting the international standards and only secondarily on the measurement units. The report recommends the development of a firm U.S. policy on participation in international standardization and product certification, without awaiting the outcome of the U.S. Metric Study.

3.7. APPLIED MATHEMATICS SERIES

No publications in this series were issued during the period covered by this publication. Previously issued Applied Mathematics Series publications are listed in the predecessor volumes of this catalog. (Miscellaneous Publication 240, Supplement to Miscellaneous Publication 240, Special Publication 305, and Supplement 1 to Special Publication 305.)

3.8. NATIONAL STANDARD REFERENCE DATA SERIES

Includes the evaluated reference data and critical reviews of long-term interest that are produced by data centers within the NSRDS network. The National Standard Reference Data System is a Government-wide effort to provide the U.S. technical community with effective access to the quantitative data of physical science, critically evaluated and compiled for convenience.

NSRDS-NBS21. **Kinetic data on gas phase unimolecular reactions,** S. W. Benson, H. E. O'Neal, Nat. Bur. Stand. (U.S.), Nat. Stand. Ref. Data Series 21, 645 pages, (Feb. 1970).

Key words: Arrhenius parameters; chemical kinetics; critical review data; gas phase; mechanisms; molecular reactions; rate constants; reaction rates.

Available rate data on thermally induced, unimolecular, homogeneous gas phase reactions of molecules and free radicals have been reviewed and critically evaluated. Introductory discussion is given of theory and assumptions used in compiling the selected data. Mechanisms of reaction are discussed. The major portion (537 out of 617 pages) of the work presents selected data, with references, in the form of data sheets (one to two pages per molecule). Preferred values are indicated and discussed.

NSRDS-NBS31. **Bond dissociation energies in simple molecules,** B. deB. Darwent, Nat. Bur. Stand. (U.S.), Nat. Stand. Ref. Data Series 31, 52 pages (January 1970).

Key words: Bond dissociation energy; gaseous state; inorganic simple compounds; recommended value; zero vibrational state of the ground electronic state.

Bond dissociation energy values (kcal/mol) and (kJ/mol) of simple compounds are tabulated from a literature review covering the years 1962-1966 inclusively. Some selected values which appeared in the years 1956-1962 are also included. Organic compounds are excluded except those containing one carbon atom. The groups $>CO$ and $-CN$ are not considered to be organic.

The values are quoted usually at 0 K or 298 K and refer to the gaseous state. They represent the energy required to break a bond at the specified temperature with all substances in the zero vibrational state of the ground electronic state. The experimental method for the energy value listed is given and referenced in the table. A value recommended by the author is listed as the final value for each reaction.

NSRDS-NBS32. **Phase behavior in binary and multicomponent systems at elevated pressures: *n*-pentane and methane-*n*-pentane,** V. M. Berry and B. H. Sage, Nat. Stand. Ref. Data Ser., Nat. Bur. Stand. (U.S.), 32, 73 pages (June 1970).

Key words: Evaluated data; liquid-vapor equilibria; methane-*n*-pentane system; *n*-pentane; thermodynamics.

This paper, which is concerned with the critical evaluation of data on the phase behavior of binary systems, consists of three parts. In the first part the rationale of the evaluation process used is discussed, in the second the behavior of *n*-pentane, and in the third the behavior of the system methane-*n*-pentane.

The properties of *n*-pentane considered are the critical constants and the vapor pressures and densities of the saturated coexistent phases as functions of temperature. For the methane-*n*-pentane system the compositions and densities of the coexisting phases are given as functions of temperature and total pressure. Data for the unique states of the two-component system are also presented.

Discussions are given of the reliability of the selected values and of the differences between the selected values and various measured values.

NSRDS-NBS33. **Electrolytic conductance and the conductances of the halogen acids in water,** W. J. Hamer and H. J. DeWane, Nat. Stand. Ref. Data Ser., Nat. Bur. Stand. (U.S.), 33, 37 pages (May 1970).

Key words: Conductances of HF, HCl, HBr, and HI; electrolytic conductance; theories of electrolytic conductance.

Definitions, symbols, general principles, and general laws related to the electrolytic conductance of aqueous solutions are presented. The general laws considered are Coulomb's law for charged bodies, Poisson's equation relating the electrostatic potential to charge distribution, and the Stokes and Oseen laws for the velocity of a sphere in a fluid medium. The relations between electrical resistance, electrical conductance, specific resistance, specific conductance, and equivalent conductance are set forth. Theoretical expressions for the equivalent conductance as derived by Debye, Onsager, and Fuoss are given in general form and in a somewhat more detailed fashion in an appendix. The general methods of treating the equivalent conductances of ionophores and ionogens, especially in regard to the determination of the limiting equivalent conductance, the degree of ionic association, and the degree of ionic dissociation are discussed. Data on the equivalent conductances of the halogen acids, hydrofluoric, hydrochloric, hydrobromic, and hydriodic acids in water are given for a wide range of concentration and temperature.

NSRDS-NBS34. **Ionization potentials and ionization limits derived from the analyses of optical spectra,** C. E. Moore, Nat. Stand. Ref. Data Ser., Nat. Bur. Stand. (U.S.), 34, 22 pages (Sept. 1970).

Key words: Atomic spectra, ground terms; ground terms, atomic spectra; ionization limits; ionization potentials.

A current table of ionization potentials expressed in electron volts and a detailed table giving the limits from which they have been derived are presented. For each spectrum the ground term is given, with the limit as the ground state. The energy levels of terms of the lowest configuration determined from ground state zero, are also included for selected spectra. The literature references used for each spectrum are indicated by number and listed in a bibliography with some 200 entries.

The latest recommended conversion factor (cm^{-1} to eV) 0.000123981 corresponding to $1 \text{ eV} = 8065.73 \text{ cm}^{-1}$ has been used throughout.

3.9. BUILDING SCIENCE SERIES

Disseminates technical information developed at the Bureau on building materials, components, systems, and whole structures. The series presents research results, test methods, and performance criteria related to the structural and environmental functions and the durability and safety characteristics of building elements and systems.

These publications, similar in style and content to the NBS Building Materials and Structure Reports (1938-59), are directed toward the manufacturing, design, and construction segments of the building industry, standards organizations, officials responsible for building codes, and scientists and engineers concerned with the properties of building materials.

BSS0. **Building research at the National Bureau of Standards,** P. R. Achenbach, Nat. Bur. Stand. (U.S.), Bldg. Sci. Ser. 0, 59 pages (Oct. 1970).

Key words: Building materials; building performance; building research; building systems; building technology; history.

The history of building research and technology at the National Bureau of Standards is as long as the history of the institution itself. The participation of the Bureau in the application of science and engineering to building materials and components played an early and important role in the development of steel and reinforced concrete as structural materials; in the understanding of physics and chemistry of cement, lime and gypsum; in the evaluation of the fire properties of building components; in safe plumbing practices; in laboratory evaluation of the effects of weather on deterioration of building materials; and in measurement of the heat and sound transmission properties of building materials and constructions. The central and continuing objectives of the building research program are shown to be the development of new technical information and new measurement methods for building materials, components, and systems, and the application of this knowledge to the specifications for Federal procurement, to the national standards of the building industry, and to the building code structure of the nation. The Bureau has served as a major technical resource in three large-scale national efforts to accelerate the construction of economical and effective buildings for housing and commercial purposes. One of these efforts is currently in progress and is characterized by an emphasis on the design of buildings to meet the performance requirements of the user rather than through the specification of the properties of the materials used.

BSS1. **Performance of buildings—concept and measurement.** Proceedings of the 1st conference in a series of Conferences on Man and His Shelter held at the National Bureau of Standards, Gaithersburg, Md., September 23-25, 1968. W. W. Walton and B. C. Cadoff, Editors, Nat. Bur. Stand. (U.S.), Bldg. Sci. Ser. 1, 132 pages (Jan. 1970).

Key words: Building systems; performance of buildings; standards; test methods; urban planning; user needs.

The Conference entitled "Performance of Buildings—Concept and Measurement" was held at the National Bureau of Standards, Gaithersburg, Md. on September 23-25, 1968. This was the first in a planned series of conferences on "Man and His Shelter." The purpose of these conferences is to bring together those people from various disciplines who may contribute to improving the quality of man's shelter. At the present conference, papers were presented by nineteen authors representing government and industry in such diverse disciplines as architecture, engineering, science, urban planning, and standards. These papers emphasize the prime importance of considering user needs in the development of performance criteria, the necessity of test methods to determine whether the desired performance has been achieved, and the development of performance specifications and standards. Application of these ideas to building systems, and to the planning and design of entire communities, is also discussed. *These proceedings include the following papers (indented)*:

BSS20. **Durability of insulating glass.** Proceedings of a seminar held at the National Bureau of Standards, Gaithersburg, Md., November 14-15, 1968, H. E. Robinson, Editor, Nat. Bur. Stand. (U.S.), Bldg. Sci. Ser. 20, 84 pages (Feb. 1970).

Key words: Accelerated laboratory tests; double-glazed window units; factory-sealed insulating glass units; field performance tests, correlation with laboratory tests; sealant performance; standardized testing; test methods.

A two-day seminar on the Durability of Insulating Glass was attended by some 130 persons on November 14 and 15, 1968. The seminar was held at the Gaithersburg, Maryland, facilities of the National Bureau of Standards and featured fourteen speakers who participated in panel discussions or delivered individual papers. Numerous agencies interested in design, manufacture, specification, purchase, installation or maintenance of windows were represented at the seminar.

Among the topics considered in the panel discussions were: (1) The need for reliability and durability of insulating glass; (2) manufacturers' test methods; (3) proposals for future action. The Canadian experience with an accelerated test method and acceptance program was presented and discussed, as were the Norwegian accelerated test methods and their correlation with field experience. A review of current practices leading to new test methods and standards was also presented, and a "round robin" program that would compare various test methods now employed in the industry was proposed. Affirmative interest in participating in the proposed round robin was expressed by about a score of manufacturers present at the seminar. *These proceedings include the following papers (indented)*:

BSS21. **Algorithms for psychrometric calculations (skeleton tables for the thermodynamic properties of moist air),** T. Kusuda, Nat. Bur. Stand. (U.S.), Bldg. Sci. Ser. 21, 53 pages (Jan. 1970).

Key words: Computer algorithm; psychrometrics; saturated and unsaturated moist air; thermodynamic properties.

Computer algorithms to obtain thermodynamic properties of saturated and unsaturated moist air are presented in this paper. The saturated moist air properties are calculated by the methodology developed by J. A. Goff and S. Gratch for their ASHRAE tables (1967 Book of Fundamentals, The American Society of Heating, Refrigerating and Air Conditioning Engineers). Sample calculations were performed using a computer program based upon the algorithms presented herein and the results are attached.

BSS22. **Investigation of performance characteristics for sanitary plumbing fixtures,** P. R. Achenbach, Project Director Coordinator, Nat. Bur. Stand. (U.S.), Bldg. Sci. Series 22, 72 pages (Jan. 1970).

Key Words: Abrasion resistance; chemical resistance; cigarette-burn resistance; cleanability and soilability; concentrated static-load capacity; performance characteristics; performance level; sanitary plumbing fixtures; scratch resistance; stain resistance; surface-impact resistance; test methods.

This report gives findings and recommendations developed during an investigation of performance characteristics for sanitary plumbing fixtures, conducted at the request of the Building Research Advisory Board of the National Academy of Sciences—National Research Council. The report describes the test methods that are recommended for the evaluation of 16 performance characteristics, and the nature of further work required to complete the development of four or five additional test procedures.

The suitability of various existing test methods for evaluating the functional and performance characteristics of sanitary plumbing fixtures was investigated in the laboratory. In addition, new or modified tests for certain characteristics were developed. The laboratory work was performed only on bathtubs and flat specimens provided by industry through appropriate arrangements with the Building Research Advisory Board. Field inspection trips were made to provide the NBS project staff with up-to-date information on certain manufacturing processes and on installation and use problems. The complexities involved in the selection of valid performance levels are discussed, as well as the elements of judgment involved. A format that might be used in specifying performance is suggested for each test procedure, and the rationale underlying each suggested format is given.

BSS26. **Radiation errors in air ducts under nonisothermal conditions using thermocouples, thermistors, and a resistance thermometer,** J. C. Davis, Nat. Bur. Stand. (U.S.), Bldg. Sci. Ser. 26, 14 pages (Nov. 1969).

Key words: Conduction error; radiation error; resistance thermometer; temperature measurement; thermistor; thermocouple.

Studies were made to determine the radiation error in temperature measurements made with thermocouples, thermistors, and a resistance thermometer in moving air at velocities ranging from 300 to 1300 fpm when the temperature of the duct wall surrounding the air stream was from 0 to 50 °F higher than that of the air in the center of the duct. To eliminate all but the variable under study, conduction errors were minimized to a point where they were almost nonexistent by using Chromel P-constantan thermocouple wire and by employing other techniques. Radiation effects were studied when the probe housing the three types of temperature sensors was unshielded and again when it was shielded. The studies showed that when the sensors were unshielded and the temperature difference between the duct wall and the air was 50 °F (28 K, approximately), the error in the sensors was about 3.8 °F (2.1 K) for an air velocity of 300 fpm (1.5 m/s) and 1.0 °F (0.6 K) for an air velocity of 1300 fpm (6.6 m/s). When the sensors were shielded, the error was about 0.2 °F (0.1 K) for 300 and 500 fpm velocities and the same duct wall air-temperature difference. Tests were not performed at 1300 fpm with the sensors shielded because theory indicated that radiation error would be negligible at this velocity. Under the test conditions that prevail in the testing of air conditioners and heat pumps in laboratories, it should be possible to reduce the error in temperature measurement of the moving air to about 0.2 °F (0.1 K) by a suitable combination of air mixers, duct insulation, radiation shields, and calibration techniques.

BSS27. **Performance of louvered devices as air mixers,** T. K. Faison, Jr., J. C. Davis, and P. R. Achenbach, Nat. Bur. Stand. (U.S.). Bldg. Sci. Ser. 27, 22 pages (Mar. 1970).

Key words: Effectiveness; forced mixing; mixing device; pressure drop; temperature; uniformity.

As part of a study of evaluating methods for reducing thermal gradients within the cross section of an air stream, three louvered mixing devices were investigated. Each of these devices was found to be capable of reducing the cross-sectional nonuniformity of air temperature to a few percent of the entering value. The three devices covered in this report contain combinations of louvers (directing vanes) and baffles as mixing elements. Two of the devices were designed at the National Bureau of Standards; the third was a modification of a previous design. The three mixers (the louvered strip, the concentric louvers, and the louvered-baffle) required 4.75, 3.8, and 3.0 duct diameters, respectively, to reach a mixing effectiveness level of 97 percent. The mixing effectiveness of the louvered strip and concentric louver models was independent of the approach velocity, whereas the effectiveness of the louver-baffle model was somewhat dependent on the approach velocity. The pressure drops accompanying air flow through the mixers, expressed as multiples of the velocity head of the entering air, were approximately 7, 5, and 38 for the louvered strip, concentric louver, and louver-baffle mixers, respectively.

BSS28. **Exploratory studies of early strength development in portland cement pastes and mortars,** R. L. Blaine and L. A. Tomes, Nat. Bur. Stand. (U.S.), Bldg. Sci. Ser. 28, 14 pages (July 1970).

Key words: Cement; cement mortar; cement paste; early strength; false set; hardening of cement; hydration; shear resistance; theory of cement hardening; time of set; vane-shear apparatus.

A modified vane-shear apparatus was used to measure the shear resistance of neat cement pastes of normal consistency and 1:2.75 (cement to sand) mortars of standard consistency, and to measure the increase in shear resistance with time as the cements hardened. The hardening process appeared to occur in three stages. The rate of increase of shear resistance as well as the duration of the different phases differed with the different cements. The results were analyzed in terms of the various theories proposed to explain the hardening of cements.

BSS29. **1964 exposure test of porcelain enamels on aluminum—three year inspection,** M. A. Baker, Nat. Bur. Stand. (U.S.), Bldg. Sci. Ser. 29, 13 pages (April 1970).

Key words: Color; gloss; porcelain enamel on aluminum; weather resistance.

An exposure test of porcelain enamels on aluminum was initiated by the National Bureau of Standards and the Porcelain Enamel Institute in 1964. The enamels were returned from the exposure sites to the laboratory at NBS to be measured for changes in gloss and color after exposures of six months, one year, and three years. Changes were found to be greatest at Kure Beach and least at Montreal and Los Angeles, with moderate changes occurring at Washington and New York.

Although the boiling citric acid test is used as an acceptance test for these enamels, the correlation with color change, particularly at Kure Beach, was not as good as expected. A cupric chloride test was developed which shows an improvement in this correlation.

BSS31. **Flexural behavior of prestressed concrete composite Tee-beams,** J. O. Bryson and E. F. Carpenter, Nat. Bur. Stand. (U.S.), Bldg. Sci. Ser. 31, 14 pages (July 1970).

Key words: Composite concrete construction; prestressed concrete beams; Tee-beams.

Prestressed Tee-beams constructed by the split-beam method were tested to failure in flexure to study the behavior and ultimate strength of these beams and to compare their flexural characteristics with those of prestressed beams of conventional construction. The compressive portion of the cross section of the split-beam is cast after the web of the beam has been formed and prestressed. The variables in the study included the precentage of prestressing steel, strength of concrete in the compressive element of the composite split-beams, manner of prestressing and web reinforcement.

Results showed that the composite split-beams behaved similarly to the monolithically constructed beams on the basis of flexural response and ultimate load. The strength of the concrete for the compressive element can be reduced within limits from that required for the prestressed element without sacrificing ultimate load capacity. The required percentage of reinforcing steel is less for the split-beam compared with conventional beams.

BSS33. **Compressive strength of slender concrete masonry walls,** F. Y. Yokel, R. G. Mathey, and R. D. Dikkers, Nat. Bur. Stand. (U.S.), Bldg. Sci. Ser. 33, 32 pages (Dec. 1970).

Key words: Buckling; compressive strength; concrete block walls; elastic stability; flexural strength; masonry walls; reinforced concrete masonry walls; slenderness effect; structural stability.

Sixty reinforced and unreinforced concrete masonry walls of different slenderness ratios were tested to failure under vertical loads applied axially and at various eccentricities. Prism specimens, made of similar masonry units and mortars, were also tested under the same loading conditions. Analysis of test results indicates that wall strength can be conservatively predicted by evaluating cross-sectional wall capacity on the basis of prism strength and reducing the capacity for slenderness effects by evaluating the added moments attributable to wall deflection. Test results were also compared with allowable loads computed in accordance with the current NCMA standard.

3.10. FEDERAL INFORMATION PROCESSING STANDARDS PUBLICATIONS

The publications in this series collectively constitute the Federal Information Processing Standards Register. The purpose of the Register is to serve as the official source of information in the Federal Government regarding (1) uniform Federal information processing standards resulting from provisions of Public Law 89-306 (the Brooks Bill), and (2) data elements and codes standards in data systems developed under the provisions of Bureau of the Budget Circular No. A-86. FIPS PUBS will include approved Federal information processing standards information of general interest, and a complete index of relevant standards publications.

FIPS PUB 5-1. **States and outlying areas of the United States. Federal General Data Standard Representations and Codes,** Nat. Bur. Stand. (U.S.), Fed. Info. Process. Stand. Publ. (FIPS Pub) 5-1, 4 pages (1970).

Key words: ADP standards; computers; data elements and codes; data processing; Federal Information Processing Standards; geography; information processing standards; information systems; National Government; representations and codes; standards; states; statistical data.

This publication provides names, abbreviations, and codes for representing the 50 States, the District of Columbia, and the outlying areas, all of which are considered to be "first order subdivisions" of the United States for use in the interchange of formatted machine sensible data. (Supersedes FIPS Pub. 5.)

FIPS PUB. 6-1. **Counties and county equivalents of the States of the United States (Federal general data standard representations and codes),** Nat. Bur. Stand. (U.S.), Fed. Info. Process. Stand. Publ. (FIPS Pub.) 6–1, 34 pages (1970).

Key words: ADP standards; computers; data elements and codes; data processing; Federal Information Processing Standards; geography; information processing standards; information systems; national government; representations and codes; standards; statistical data.

This publication provides names and codes for representing the Counties of the 50 States or county equivalents thereof for use in the interchange of formatted machine sensible data. Also included in the set of codes are the independent cities of Maryland, Missouri, Nevada, and Virginia and the Census Divisions and boroughs of Alaska. (Supersedes FIPS Pub. 6.)

FIPS PUB10. **Countries, dependencies and areas of special sovereignty. Federal General Data Standard Representations and Codes,** Nat. Bur. Stand. (U.S.), Fed. Info. Process. Stand. Publ. (FIPS Pub) 10, 23 pages (1970).

Key words: ADP standards; computers; data elements and codes; data processing; Federal Information Processing Standards; geography; information processing standards; information systems; representations and codes; standards; statistical data.

This publication provides a list of basic geographical-political entities of the world and associated standard codes. These entities include independent states, dependent areas, areas of quasi-independence, noncontiguous territories, possessions without population, areas with special sovereignty associations, areas without sovereignty, political regimes not recognized by the United States, and outlying areas of the United States.

FIPS PUB. 11. **Vocabulary for information processing,** J. L. Walkowicz, Standards Coordinator, Nat. Bur. Stand. (U.S.), Fed. Info. Process. Stand. Publ. (FIPS Pub.) 11, 4 pages (1970).

Key words: Computers; data processing; definitions, Federal Information Processing Standards Publication; information processing; terms; vocabulary.

This publication provides an alphabetic listing of approximately 1200 entries, each consisting of a term and its definition, for use in information processing activities such as the description, representation, communication, interpretation, and processing of data by human or automatic means.

Multiple-word terms are listed in their natural order; terms with identical last words appear as "See references" under the common word. Other reference symbols indicate synonyms, preferred terms, contrasting meanings, and unabbreviated forms for defined terms which are acronyms or abbreviations.

3.11. PRODUCT STANDARDS

This series comprises voluntary standards that establish (1) dimensional requirements for standard size and types of various products, (2) technical requirements for the product, and (3) methods of testing, grading, and marking these products. The objective is to define requirements for products in accordance with the principal demands of the trade.

PS10-69. **Polyethylene (PE) plastic pipe (schedule 40 – inside diameter dimensions)**, H. A. Philo, Technical Standards Coordinator, Nat. Bur. Stand. (U.S.), Prod. Stand. 10-69, 14 pages (Mar. 1970).

Key words: Dimensions; inside diameter; materials; pipe; polyethylene plastic; schedule 40.

This Product Standard covers the principal materials, sizes, and pressure ratings for commercially available PE plastic pipe made in Schedule 40 size with the inside diameter controlled for use with insert fittings. Included are requirements and methods of test for materials, workmanship, dimensions, sustained pressure, burst pressure, and environmental stress cracking.

PS11-69. **Polyethylene (PE) plastic pipe (SDR)**, H. A. Philo, Technical Standards Coordinator, Nat. Bur. Stand. (U.S.), Prod. Stand. 11-69, 14 pages (Mar. 1970).

Key words: Inside diameter dimensions; materials; pipe; polyethylene (PE); pressure; standard dimension ratio (SDR).

This Product Standard covers the principal materials, sizes and pressure ratings for commercially available PE pipe made in Standard Dimension Ratios with the inside diameter controlled for use with insert fittings. Included are requirements and methods of test for materials, workmanship, dimensions, sustained pressure, burst pressure, and environmental stress cracking.

PS12-69. **Polyethylene (PE) plastic pipe (schedules 40 and 80 – outside diameter dimensions)**, H. A. Philo, Technical Standards Coordinator, Nat. Bur. Stand. (U.S.), Prod. Stand. 12-69, 14 pages (Mar. 1970).

Key words: Dimensions; materials; outside diameter; pipe; polyethylene (PE); schedule size (40 and 80).

This Product Standard covers the principal types, grades, sizes, and pressure ratings for commercially available PE plastic pipe made in Schedule 40 and 80 sizes with the outside diameter controlled for use with socket-type fittings. Included are requirements and methods of test for materials, workmanship, dimensions, sustained pressure, burst pressure, and environmental stress cracking.

PS14-69. **Salt packages**, C. B. Phucas, Technical Standards Coordinator, Nat. Bur. Stand. (U.S.), Prod. Stand. 14-69, 9 pages (May 1970).

Key words: Salt; salt packages; sodium chloride.

This Product Standard specifies the recommended salt packages for each kind of salt, the labeled net weight of the packages, and the type and capacity of shipping containers. Definitions and uses for salt are also included. While no attempt is made to list all of the packages, sizes, and containers which might be packed by one or more producer, table 1 includes those items common to the entire industry.

PS15-69. **Custom contact-molded reinforced-polyester chemical-resistant process equipment**, D. R. Stevenson, Technical Standards Coordinator, Nat. Bur. Stand. (U.S.), Prod. Stand. 15-69, 28 pages (June 1970).

Key words: Chemical-resistant; contact-molded; ducts; equipment; plastic; reinforced-polyester; tanks.

This Product Standard covers materials, construction and workmanship, physical properties, and methods of testing reinforced-polyester materials for process equipment and auxiliaries intended for use in aggressive chemical environments, including but not limited to pipe, ducts, and tanks. The Standard is based on the technology of fabrication by hand lay-up or contact pressure molding. Methods for identifying products which comply with the requirements of this Standard are included.

PS16-69. **Types and sizes of forms for one-way concrete joist construction**, J. W. Eisele, Technical Standards Coordinator, Nat. Bur. Stand. (U.S.), Prod. Stand. 16-69, 16 pages (June 1970).

Key words: Concrete; floor and roof; forms joist; one-way.

This Product Standard covers four types of forms for one-way concrete joist construction and standard sizes for these types. Definitions of concrete joist construction and one-way joist construction are provided under section 4. (Supersedes NBS Simplified Practice Recommendation 87-32.)

PS17-69. **Polyethylene sheeting (construction, industrial, and agricultural applications)**, D. R. Stevenson, Technical Standards Coordinator, Nat. Bur. Stand. (U.S.), Prod. Stand. 17-69, 20 pages (June 1970).

Key words: Agricultural; composition; construction; industrial; polyethylene; properties; sheeting.

This Product Standard covers polyethylene sheeting of 10 mils (0.010 inch) or less in thickness and establishes requirements for the composition, impact resistance, mechanical properties, reflectance, opaqueness (low luminous transmittance), water vapor transmission, weight, and appearance of the sheeting. Also included are tolerance requirements for the thickness width and length of the sheeting. Provisions for identifying polyethylene sheeting conforming to this Standard are also provided. (Supersedes Commercial Standard CS238-61.)

PS18-69. **Acrylonitrile-butadiene-styrene (ABS) plastic pipe (schedules 40 and 80)**, K. G. Newell, Jr., Technical Standards Coordinator, Nat. Bur. Stand. (U.S.), Prod. Stand. 18-69, 15 pages (June 1970).

Key words: Acrylonitrile-butadiene (ABS), outside diameter; dimensions; pipe; schedule size (40 and 80).

This Product Standard covers the principal types, grades, sizes, and pressure ratings for commercially available ABS plastic pipe made in Schedule 40 and 80 sizes with the outside diameter controlled. Included are requirements and methods of test for materials, workmanship, dimensions, sustained pressure, and burst pressure. Methods of marking and labeling to indicate compliance with this Standard are also provided. (Supersedes Commercial Standard CS218-59.)

PS19-69. **Acrylonitrile-butadiene-styrene (ABS) plastic pipe (Standard dimension ratio)**, K. G. Newell, Jr., Technical Standards Coordinator, Nat. Bur. Stand. (U.S.), Prod. Stand. 19-69, 13 pages (June 1970).

Key words: Acrylonitrile-butadiene-styrene (ABS); outside diameter dimensions; pipe; standard dimension ratio (SDR).

This Product Standard covers the principal types, grades, sizes, and pressure ratings of commercially available ABS plastic pipe made in Standard Dimension Ratios (SDR) with the outside diameter controlled. Included are requirements and methods of test for materials, workmanship, dimensions, sustained pressure, and burst pressure. Methods of marking and labeling to indicate compliance with this Standard are also provided. (Supersedes Commercial Standard CS254-63.)

PS20-70. **American softwood lumber standard,** D. R. Mackay, Technical Standards Coordinator, Nat. Bur. Stand. (U.S.), Prod. Stand. 20-70, 26 pages (Jan. 1970).

Key words: Grades; lumber; sizes; softwood; species; timber.

This Product Standard covers the principal trade classifications and sizes of softwood lumber for yard, structural, and shop use. It provides a common basis of understanding for the classification, measurement, grading, and grade marking of rough and dressed sizes of various items of lumber, including finish, boards, dimension, and timbers. (Supersedes NBS Simplified Practice Recommendation 16-53.)

PS21-70. **Poly(vinyl chloride) (PVC) plastic pipe (schedules 40, 80, and 120),** K. G. Newell, Jr., Technical Standards Coordinator, Nat. Bur. Stand. (U.S.), Prod. Stand. 21-70, 16 pages (June 1970).

Key words: Dimensions; hydrostatic design stress; materials; pipe; poly(vinyl chloride) (PVC); pressure; pressure rating (PR); schedule 40, 80, and 120 sizes.

This Product Standard covers the principal types, grades, sizes, and pressure ratings for commercially available PVC plastic pipe made in Schedule 40, 80, and 120 sizes, with the outside diameter controlled. Included are requirements and methods of test for materials, workmanship, dimensions, sustained pressure, burst pressure, flattening, and extrusion quality. Methods of marking and labeling to indicate compliance with this Standard are also provided. (Supersedes Commercial Standard CS207-60.)

PS22-70. **Poly(vinyl chloride) (PVC) plastic pipe (standard dimension ratio),** K. G. Newell, Jr., Technical Standards Coordinator, Nat. Bur. Stand. (U.S.), Prod. Stand. 22-70, 14 pages (June 1970).

Key words: Class T; dimensions; hydrostatic design stress; materials; pipe; poly(vinyl chloride) (PVC); pressure; pressure rating (PR); standard dimension ratio (SDR); threads.

This Product Standard covers the principal types, grades, sizes, and pressure ratings for commercially available PVC plastic pipe made in Standard Dimension Ratios (SDR) with the outside diameter controlled. Included are requirements and methods of test for materials, workmanship, dimensions, sustained pressure, burst pressure, flattening, and extrusion quality. Methods of marking and labeling to indicate compliance with this Standard are also provided. (Supersedes Commercial Standard CS256-63.)

PS23-70. **Horticultural grade perlite,** J. W. Eisele, Technical Standards Coordinator, Nat. Bur. Stand. (U.S.), Prod. Stand. 23-70, 9 pages (May 1970).

Key words: Horticultural grade; perlite horticultural grade.

This Product Standard includes requirements for the grading, density, pH value, and sterility of horticultural grade perlite and gives test methods for these requirements with the exception of sterility. A provision for identifying a product as conforming to the Standard is included.

PS24-70. **Melamine dinnerware (alpha-cellulose-filled) for household use,** D. R. Stevenson, Technical Standards Coordinator, Nat. Bur. Stand. (U.S.), Prod Stand. 24-70, 9 pages (Aug. 1970).

Key words: Alpha-cellulose-filled; dinnerware; household alpha-cellulose filled melamine dinnerware; household use; melamine dinnerware; melamine plastic.

This Product Standard covers the properties, the methods of test, and the thickness and weight of household dinnerware molded from alpha-cellulose-filled melamine-formaldehyde and other amino-triazine-formaldehyde plastic materials. Requirements for the finish and decorations are also covered by the Standard. Methods for identifying melamine dinnerware complying with the requirements of this Standard are provided.

This Standard does not cover the design or color of melamine dinnerware.

PS25-70. **Heavy-duty alpha-cellulose-filled melamine tableware,** D. R. Stevenson, Technical Standards Coordinator, Nat. Bur. Stand. (U.S.), Prod. Stand. 25-70, 8 pages (Aug. 1970).

Key words: Alpha-cellulose-filled, heavyduty; heavyduty alpha-cellulose-filled melamine tableware; melamine tableware; tableware.

This Product Standard covers the thickness, properties, and methods of test for heavy-duty tableware molded from alpha-cellulose-filled melamine-formaldehyde and other amino-triazine-formaldehyde plastic materials. Requirements for the finish and decoration are also covered by the Standard. Methods for identifying melamine tableware complying with the requirements of this Standard are provided.

This Standard does not cover the design, size, or color of the melamine tableware.

PS26-70. **Rigid poly(vinyl chloride) (PVC) profile extrusions,** D. R. Stevenson, Technical Standards Coordinator, Nat. Bur. Stand. (U.S.), Prod. Stand. 26-70, 7 pages (Oct. 1970).

Key words: Extrusions; poly(vinyl chloride); profile; profile extrusions; PVC profile extrusions; rigid PVC.

This Product Standard establishes requirements for the material and properties, including dimensional stability and extrusion quality, of rigid PVC profile extrusions. Methods for identifying profile extrusions that comply with the requirements of this Standard are provided.

PS27-70. **Mosaic-parquet hardwood slat flooring,** W. H. Furcolow, Technical Standards Coordinator, Nat. Bur. Stand. (U.S.), Prod. Stand. 27-70, 13 pages (Sept. 1970).

Key words: Flooring; hardwood flooring; mosaic-parquet flooring; slat flooring.

This Product Standard covers requirements for grading, moisture content, dimensions, construction, and finish for mosaic-parquet hardwood slat flooring which is intended for use in residential, institutional, and commercial buildings. A method for marking and labeling to indicate compliance with the Standard is also provided. Manufacturers' recommendations on ordering and installation are included in an appendix. The Standard does not cover flooring squares or blocks which are fabricated from conventional tongue and groove type strips.

PS28-70. **Glass stopcocks with polytetrafluoroethylene (PTFE) plugs,** C. B. Phucas, Technical Standards Coordinator, Nat. Bur. Stand. (U.S.), Prod. Stand. 28-70, 10 pages (Sept. 1970).

Key words: Glass stopcocks with PTFE plugs; glass with PTFE plugs; PTFE plugs for glass stopcocks; stopcocks.

This Product Standard covers the design, dimensions, tolerances, and performance criteria for glass stopcocks with PTFE plugs. Also included are methods of marking and labeling to indicate compliance with this Standard. This Product Standard does not cover glass stopcocks with glass plugs, nor glass stopcocks intended for use in high vacuum work.

3.12. TECHNICAL NOTES

Designed to supplement the Bureau's regular publications program, Technical Notes provide a publication medium for communications and reports on data of limited or transitory interest. They often serve as final reports on work sponsored at NBS by other Government agencies.

TN383. **A bibliography of thermophysical properties of air from 0 to 300 K,** L. A. Hall, Nat. Bur. Stand. (U.S.), Tech. Note 383, 121 pages (Oct. 1969).

Key words: Air; bibliography; equation of state; low temperature; mechanical properties; thermodynamic properties; transport properties.

References together with an abbreviated abstract are presented for mechanical, thermodynamic, and transport properties of air from 0 to 300 K published up to December 1968. A total of 610 articles have been indexed. Each article has been reviewed and coded with regard to properties studied, type of article (i.e., experimental, theoretical, etc.), and method of presentation of data. The temperature and pressure ranges for each property under consideration are also given. An index has been prepared according to property with four sub-categories: solid, liquid, gas up to 200 K, and gas above 200 K.

TN385. **Thermal conductance at the interface of a solid and helium II (Kapitza conductance),** N. S. Snyder, Nat. Bur. Stand. (U.S.), Tech. Note 385, 90 pages (Dec. 1969).

Key words: Heat transfer; helium II; Kapitza conductance.

A review is presented of the experimental and theoretical work on Kapitza conductance, including a compilation of the available data on conductance to helium II. A short derivation of the phonon radiation limit indicates the reason for the approximate T^3 temperature dependence and the small size of the Kapitza conductance for most solids. Considerable qualitative and quantitative correspondence of the data with this limit is found. From the limited evidence available, the role of surface conditions, and of bulk parameters such as the Debye temperature in determining the conductance are considered empirically. Theoretical knowledge of the Kapitza conductance is seen to give an inadequate explanation of the data. In addition, the phenomena which occur when the heat flux is high enough that properties of the bulk liquid are also involved in the measured conductance are described briefly.

TN386. **A precision, high frequency calibration facility for coaxial capacitance standards,** R. N. Jones and L. E. Huntley, Nat. Bur. Stand. (U.S.), Tech. Note 386, 27 pages (Mar. 1970).

Key words: Calibration; capacitance; capacitance, measurement; coaxial capacitance standards; impedance, measurements, capacitance; standards; statistical control.

Using high frequency impedance standards which are fitted with precision coaxial connectors, and limiting calibrations to specific frequencies and impedance values, can contribute greatly toward improving measurement agreement and standardization. These advantages have been utilized in the development of a new and much improved calibration service for capacitance in the high frequency region. The service is for capacitances of 50, 100, 200, 500 and 1000 picofarads at 100 kHz, 1 MHz, and 10 MHz. This paper describes the instrumentation used in the measurements and the method of data handling, and gives a detailed breakdown of the measurement uncertainties.

TN387. **Hydrogen spin exchange frequency shifts,** H. Hellwig, Nat. Bur. Stand. (U.S.), Tech. Note 387, 13 pages (Mar. 1970).

Key words: Frequency pulling; hydrogen beam tube; hydrogen maser; maser tuning; spin exchange.

Frequency shifts due to hydrogen spin exchange collisions are discussed for the hydrogen maser and the hydrogen storage beam tube. The combined effects of spin exchange and cavity pulling in the hydrogen maser are evaluated with emphasis on frequency errors introduced by standard tuning procedures. It is found that an automatic cavity tuning system based on a variation of the linewidth does not introduce a frequency error. In contrast, manual tuning procedures based on an interpolation of measurements at different cavity settings do not yield a perfect compensation of spin exchange effects. However, the frequency error becomes only significant at unnecessarily large cavity offsets.

The smallness of the spin exchange shifts and the near absence of cavity pulling in a hydrogen storage beam tube are expected to permit a determination of spin exchange shifts by varying the beam intensity with a precision adequate for stability and accuracy figures of 10^{-14} or better.

TN389. **Quantifying hazardous electromagnetic fields: Practical considerations,** R. R. Bowman, Nat. Bur. Stand. (U.S.), Tech. Note 389, 15 pages (Apr. 1970).

Key words: Electromagnetic fields; field parameters; hazards; instrumentation; quantifying.

The usefulness of power density to express the hazard potential of electromagnetic fields is limited to simple fields that are approximately uniform and plane wave. For fields that are complicated by having reactive components or by having multipath interference patterns, power density is not a suitable parameter for quantifying the potential hazards because: (a) such fields can be very strong even though the power density is small, and (b) the power density in such fields is very difficult to measure. Since some of the most important hazardous fields can involve very complicated field configurations (for instance, fields near leaking cracks in microwave ovens), it is important to establish a more rational measure for hazardous fields. A qualitative discussion is given of the many issues involved in selecting a suitable field parameter for quantifying hazardous electromagnetic fields in general. It is concluded that the total energy density of the field is the best parameter, but in many instances the electric energy density alone will be adequate. Some general discussion is given concerning "ideal" instrumentation for quantifying hazardous fields.

TN390. **Far infrared absorption in liquefied gases,** M. C. Jones, Nat. Bur. Stand. (U.S.), Tech. Note 390, 39 pages (Apr. 1970).

Key words: Absorption coefficient; argon; carbon monoxide; far infrared; hydrogen; liquefied gases; methane; nitrogen; oxygen.

Experimental results are given for the absorption coefficient of the liquids hydrogen (three para concentrations), nitrogen, oxygen, carbon monoxide, methane and argon in the wave number range 20-250 cm^{-1} (40-500 μm). In addition, data for liquid hydrogen are given at wave numbers up to 600 cm^{-1} (16.7 μm). The results are discussed in terms of the induced dipole, and, in the case of carbon monoxide, the permanent dipole. An indication of the way in which the data may be employed in calculations of thermal radiative transfer is made by calculation of the modified Planck mean absorption coefficient.

TN391. **Quantifying hazardous microwave fields: analysis,** P. F. Wacker, Nat. Bur. Stand. (U.S.), Tech. Note 391, 19 pages (Apr. 1970).

Key words: Electromagnetic radiation; energy density; hazards; measurement; microwave radiation; probe; radiation; standards.

The familiar power density radiation hazard standards are quite satisfactory for a field consisting of a single infinite traveling plane wave. However, for microwave and lower-frequency fields, hazards occur primarily in near fields which cannot be approximated as the aforementioned plane wave. Further, power density can be quite misleading or even meaningless as a measure of hazard in a near field. Thus, power density in a standing wave can be precisely zero, yet the hazard of such a field can be arbitrarily large. Similarly, a reactive field may present a considerable hazard, yet have zero time-average power density.

The major hazard from microwave and lower frequency radiation is believed to arise from dielectric heating of body tissues, and the heating of an isotropic medium is proportional to the sum of the squares of the absolute values of the electric field components $|E_x|^2 + |E_y|^2 + |E_z|^2$. Hence, electric field energy density is proposed for a radiation hazard standard.

Analytical limitations of various types of probes are considered and the advantages of a spherically-symmetric probe of lossy dielectric are discussed. For a rather general spherically-symmetric probe in an arbitrary field, both exact and approximate treatments are given for the calibration constant with full correction for the perturbation of the field by the probe. Conditions for a constant factor are also given.

TN392. **The thermodynamic properties of compressed gaseous and liquid fluorine,** R. Prydz. and G. C. Straty, Nat. Bur. Stand. (U.S.), Tech. Note 392, 182 pages (Oct. 1970).

Key words: Density; enthalpy; entropy; fixed points (PVT); fluorine; Joule-Thomson; latent heat; melting curve; PVT measurements; saturation densities; specific heats; vapor pressure; velocity of sound; virial coefficients.

An apparatus has been constructed and used successfully to measure vapor pressure and PVT data of fluorine from the triple point to 300 K at pressures to about 24 MN/m^2. Material problems caused by the toxic and corrosive nature of fluorine were solved. A network of isotherm and isochore polynomials and a truncated virial equation were used to represent all PVT data. These equations represent the data with an average standard deviation of about 0.02 percent in density, the corresponding accuracy being estimated at 0.1 percent. Equations for the saturated liquid and vapor densities, the vapor pressure curve, the melting line, and the ideal gas properties are also presented. Comparisons are given to published values of the second virial coefficients, vapor pressures, and saturation densities. Additional comparisons are also made to measured specific heats and latent heats of vaporization. New values are reported for the triple point and critical point parameters together with the temperature and saturation densities at the normal boiling point. Finally, extensive tables of thermodynamic properties of fluorine are given which include pressure, temperature, density, isotherm and isochore derivatives, internal energy, enthalpy, entropy, specific heats at constant pressure and volume and velocity of sound.

TN393. **A method for designing multi-screw waveguide tuners,** M. P. Weidman and E. Campbell, Nat. Bur. Stand. (U.S.), Tech. Note 393, 20 pages (Oct. 1970).

Key words: Capacitive screw tuner; impedance transformer; waveguide tuner.

Capacitive screw, waveguide tuners are commonly used in microwave measurement systems and as devices for adjusting the impedance of various waveguide terminations. The design of a broadband tuner of this type has been a problem in the past.

This paper describes a method for designing tuners which will work effectively for relatively wide ranges of frequencies.

TN394. **Characterization of frequency stability,** J. A. Barnes, A. R. Chi, L. S. Cutler, D. J. Healey, D. B. Leeson, T. E. McGunigal, J. A. Mullen, W. L. Smith, R. Sydnor, R. F. C. Vessot, and G. M. R. Winkler, Nat. Bur. Stand. (U.S.), Tech. Note 394, 50 pages (Oct. 1970).

Key words: Allan variance; frequency; frequency stability; sample variance; spectral density; variance.

Consider a single generator whose instantaneous output voltage $V(t)$ may be written as

$$V(t) = [V_0 + \epsilon(t)] \sin [2\pi\nu_0 t + \phi(t)]$$

where V_0 and ν_0 are the nominal amplitude and frequency respectively of the output. Provided that $\epsilon(t)$ and $\phi(t) = d\phi/dt$ are sufficiently small for all time t, one may define the fractional instantaneous frequency deviation from nominal by the relation

$$y(t) \equiv \frac{\dot{\phi}(t)}{2\pi\nu_0}.$$

A proposed definition for the measure of frequency stability is the spectral density $S_y(f)$ of the function $y(t)$ where the spectrum is considered to be one-sided on a per hertz basis.

An alternative definition for the measure of stability is the infinite time average of the sample variance of two adjacent averages of $y(t)$: that is, if

$$\bar{y}_k = \frac{1}{\tau}\int_{t_k}^{t_k+\tau} y(t)dt,$$

where τ is the averaging period, $t_{k+1} = t_k + T$, $k = 0, 1, 2 \ldots$, t_0 is arbitrary, and T is the time interval between the beginnings of two successive measurements of average frequency; then the second measure of stability is

$$\sigma_y^2(\tau) \equiv \left\langle \frac{(\bar{y}_{k+1} - \bar{y}_k)^2}{2} \right\rangle,$$

where $\langle\ \rangle$ denotes infinite time average and where $T = \tau$.

In practice, data records are of finite length and the infinite time averages implied in the definitions are normally not available; thus estimates for the two measures must be used. Estimates of $S_y(f)$ would be obtained from suitable averages either in the time domain or the frequency domain. An obvious estimate for $\sigma_y^2(\tau)$ is

$$\sigma_y^2(\tau) \approx \frac{1}{m}\sum_{k=1}^{m} \frac{(\bar{y}_{k+1} - \bar{y}_k)^2}{2}.$$

Parameters of the measuring system and estimating procedure are of critical importance in the specification of frequency stability. In practice, one should experimentally establish confidence limits for an estimate of frequency stability by repeated trials.

TN492. **Component combination and frame-embedding in Chinese character grammars,** K. Rankin and J. L. Tan, Nat. Bur. Stand. (U.S.), Tech. Note 492, 36 pages (Feb. 1970).

Key words: Blocking; Chinese characters; component combination; frame-embedding; generative grammar; grammar; linguistics.

Chinese characters can be almost completely described from the point of view that each character is composed of a number of components and that each component is composed of a number of strokes. This note offers a grammatical treatment of component combination. It is concerned with the three most productive processes of component arrangement. This grammar differs from previous grammars in that the constraints on recursion have been minimized and great lexical economy has been achieved.

TN498. **Bibliographies on fabric flammability. Part 1. Wearing apparel. Part 2. Fabrics used on beds. Part 3. Carpets and rugs,** S. H. Greenfeld, E. R. Warner, and H. W. Reinhart, Nat. Bur. Stand. (U.S.), Tech. Note 498, 36 pages (Feb. 1970).

Key words: Apparel; bedding; beds; blankets; carpets; clothing; fabrics; fibers; fire; flame; flammability; flammable; floor coverings; mattresses; pillow cases; pillows; rugs; sheets; springs; wearing apparel.

As recognition of the urgency of the flammable fabrics problem, the Flammable Fabrics Act of 1953 was amended in 1967 to include all items of wearing apparel and interior furnishings. In order to facilitate research and assist in the development of new standards and test methods in these areas, a series of bibliographies is being prepared by the NBS Office of Flammable Fabrics. The first three, on wearing apparel, bed fabrics and carpets and rugs, are included in this Technical Note.

TN498-1. **Bibliographies on fabric flammability. Part 4. Interior furnishings,** S. H. Greenfeld, E. R. Warner, and H. W. Reinhart, Nat. Bur. Stand. (U.S.), Tech. Note 498-1, 24 pages (June 1970).

Key words: Bedding; beds; blankets; carpets; curtains; drapes; fabrics; fibers; fire; flames; flammability; flammable; floor coverings; furnishings; furniture; interior furnishings; mattresses; pads; pillow cases; pillows; plastics; rugs; sheets; springs; upholstered furniture; upholstery.

As recognition of the urgency of the flammable fabrics problem, the Flammable Fabrics Act of 1953 was amended in 1967 to include all items of wearing apparel and interior furnishings. In order to facilitate research and assist in the development of new standards and test methods in these areas, a series of bibliographies is being prepared by the NBS Office of Flammable Fabrics in cooperation with the NBS Library. The first three bibliographies, on wearing apparel, fabrics used on beds, and carpets and rugs, were published in NBS Technical Note 498. This one is on interior furnishings. It includes all of the references on bed fabrics and carpets and rugs that appeared in TN498, along with those on upholstered furniture, draperies, curtains, and materials that are used in interior furnishings.

TN498-2. **Bibliographies on fabric flammability. Part 5. Testing and test methods,** S. H. Greenfeld, E. R. Warner, and H. W. Reinhart, Nat. Bur. Stand. (U.S.), Tech. Note 498-2, 39 pages (Sept. 1970).

Key words: Bibliography of test methods; burning; burning rate; combustion; fire; fire retardant; flame; flame spread; gases; ignition; smoke.

This, the fifth of a series of bibliographies on fabric flammability, relates to test methods and testing of fabrics and products made from fabrics and related materials. Unlike the earlier bibliographies, which cited references to flammability of categories of fabric products, this one cuts across product lines and covers all of the products within the ranges defined in the 1967 amendment to the Flammable Fabrics Act. Approximately 300 citations are included.

TN500. **Edit-insertion programs for automatic typesetting of computer printout,** C. G. Messina, J. Hilsenrath, Nat. Bur. Stand. (U.S.), Tech. Note 500, 50 pages (Apr. 1970).

Key words: Applications, computers; computer-assisted typesetting; FORTRAN programs; KWIC index; phototypesetting; printing.

SETLST and KWIND are FORTRAN programs which accept a card deck or Fortran records on magnetic tape and insert the appropriate flags and shift symbols required by many of the "standard" typesetting programs associated with phototypesetting devices. The programs are specialized to the particular application; the typesetting device and associated programs; and to the desired typeface, by means of control cards and substitution tables supplied at run time. Examples are shown of applications to program listings, KWIC indexes, and normal computer output. When the input is in tabular form, the program permits more sophisticated operations including rearrangement, removal of trailing blanks, typeface changes between columns, etc. These programs can handle any records which can be read by a FORTRAN READ statement under an "A" format control.

TN501. **Radiochemical analysis: Mössbauer effect, nuclear chemistry, nuclear instrumentation, statistical analysis and radioisotope techniques, July 1968 to June 1969,** J. R. DeVoe, Editor, Nat. Bur. Stand. (U.S.), Tech. Note 501, 149 pages (Feb. 1970).

Key words: Calculations; conversion electrons; counting statistics; cross sections; cryostats; electric field gradient tensor; electronics; gas analysis; heterogeneity; interferometric; internal magnetic field; iron; molybdenum; Mössbauer spectrometer; Mössbauer spectrometry; nickel-61; proportional detector; radiochemistry; radioisotope dilution; rutile; self-consistent crystal field; standard reference materials; structure analysis.

This is the sixth summary of progress of the Radiochemical Analysis Section of the Analytical Chemistry Division at the National Bureau of Standards.

The section's effort comprises five major areas: Mössbauer spectroscopy, nuclear chemistry, nuclear instrumentation, radioisotope tracer techniques and the application of statistics in nuclear and analytical chemistry.

Low temperature devices for Mössbauer spectroscopy are a subject of continuing interest, and this year's effort is centered around the design of variable temperature devices. A high temperature device is also described.

Preliminary data on the detection of conversion electrons show the potential for Mössbauer spectroscopy in the field of chemical bonding in surfaces.

Further exploration of the potential of Mössbauer spectroscopy for the measure of structural parameters of nickel compounds have been made.

Preliminary data are presented on the structure of iron doped rutile (TiO_2) which is of significance to the determination of mineral structures found on the moon. Theoretical predictions of Mössbauer spectra resulting from electric field gradients due to crystal field interactions are presented. Evaluation of the basic integrals using the self-consistent Hartree-Fock method is given for ions of the first row of transition elements.

Precautions to be taken in the analysis of gamma-ray spectra are presented when model errors exist and when a gain shift is detected.

A system for gas analysis which utilizes gas chromatography is described. Its application to nuclear cross section studies is also presented. A method for setting limits on sample heterogeneity using a specific analysis method provides a useful indicator for evaluation of the adequacy of standard reference materials.

An interesting presentation of detection and measurement in the femtogram region is given.

The complete circuitry for the optical interferometric Mössbauer spectrometer is presented in this report.

Quantitative analysis for molybdenum and iron using radioisotope dilution to a precision that rivals most other techniques is described.

TN502. **Activities of the NBS Spectrochemical Analysis Section, July 1968 through June 1969,** B. F. Scribner, Editor, Nat. Bur. Stand. (U.S.), Tech. Note 502, 108 pages (Dec. 1969).

Key words: Analytical curve functions; color composite; computer programs; electron probe; gold analysis; isotope dilution method; laser probe; metal foil analysis; microanalysis; non-diffractive x-ray spectra; optical spectrometry; platinum analysis; preconcentration techniques; spark source mass spectrometry; spectrochemical analysis; spectrograph; standard reference materials; steel analysis; target current scanning; trace analysis; x-ray absorptiometry; x-ray fluorescence analysis; x-ray scans.

Spectrochemical research activities, improvements in equipment, and applications are summarized. In optical emission spectrometry micro methods were investigated and computer programs were completed for fitting analytical curves. In electron probe microanalysis studies of corrections for quantitative analysis and new gains in non-diffractive analysis and target current scanning were made. X-ray absorptiometry was applied to the analysis of thin metal foils and computer programs were improved for correction of x-ray fluorescence analysis. Chemical pre-concentration of impurities combined with isotope dilution spark source mass spectrometry found increased application in accurate trace analysis. Resolution of the mass spectrometer was improved and the behavior of ion samples was studied. Extensive involvement in the standard reference materials program contributed to certification of several SRM's including high purity Zn and Au, two sets of wires, Au-Ag and Au-Cu, for microprobe analysis, and electronic and magnetic alloys. Listings are given of 21 publications and 29 talks by members of the Section during the year.

TN506. **Analytical Mass Spectrometry Section: Summary of activities, July 1968 to June 1969,** W. R. Shields, Editor, Nat. Bur. Stand. (U.S.), Tech. Note 506, 55 pages (May 1970).

Key words: Instrumentation; isotope dilution; 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 1968 to June 1969.

Chemical and mass spectrometric procedures are described for the determinations of the absolute isotopic abundance ratios of natural rubidium, boron in a natural boric acid and a ^{10}B enriched boric acid, and of uranium in six SRMs.

Procedures are also described for the determination of trace amounts of copper and lead in steel, and silver, copper, boron and uranium in glass by isotope dilution mass spectrometry.

TN508. **Activation Analysis Section: Summary of activities, July 1968 to June 1969,** Nat. Bur. Stand. (U.S.), Tech. Note 508, 147 pages (July 1970).

Key words: Activation analysis; ancient stained glass; carbon; Cockcroft-Walton neutron generator; coincidence spectrometer; group separations; homogeneity testing; hydrated antimony pentoxide; NBS LINAC; NBS Reactor; neutron flux measurements; photofission; standard reference materials; tetracycline.

The design and installation of irradiation facilities for the NBS Reactor are described, and studies of the operating characteristics of the pneumatic tube facilities are reported. Procedures have been developed for determining molybdenum in the presence of large amounts of tungsten and for the determination of uranium. Methods for determining a contamination-free blank for application to liquid samples, and a study of the application of neutron activation to the analysis of stained glass were begun. The application of thermal and fast neutron activation analysis and photonuclear activation analysis to the NBS Standard Reference Material program is discussed. Studies have been made of the application of 3-MeV neutrons from a Cockcroft-Walton neutron generator to activation analysis and of the 3-MeV neutron buildup in 14-MeV neutron activation analysis. The determination of carbon by photonuclear activation has been extended to several metals other than sodium; thallium has been determined in glass samples by photon bombardment, and the photofission of thallium, bismuth and lead has been studied. Hydrated antimony pentoxide has been used to separate sodium from glass samples for subsequent instrumental activation analysis, and the antibiotic, tetracycline, has been applied to radiochemical separations.

TN509. **Separation and Purification Section: Summary of activities, July 1968 to June 1969,** D. H. Freeman and W. L. Zielinski, Jr., Editors, Nat. Bur. Stand. (U.S.), Tech. Note 509, 73 pages (Feb. 1970).

Key words: Gas chromatography; infrared analysis; ion exchange; liquid chromatography; purification; separation; styrene/divinylbenzene; ultrapure reagents.

This is the annual progress report on the Separation and Purification Section activities. The major task of developing a certified ion exchange microstandard as a Standard Reference Material is presented in terms of the preparative and characterizational work involved. Fundamental studies of ion exchange substrates includes the application of quantitative analytical infrared spectrophotometry to measure crosslinking in the copolymer network, and to determine the degree of sulfonation. Optical microscopy is applied to the study of swelling kinetics for single copolymer particles. Analytical gas chromatography is applied to the isomers of divinylbenzene. The recently acquired quadrupole mass spectrometer is described. Liquid chromatography at high pressures and with high resolution has been begun recently. The activities of a project dealing exclusively with ultrapure reagents is described including the problems of contamination free storage.

TN511. **Measurement methods for the semiconductor device industry—a summary of NBS activity,** W. M. Bullis. Nat. Bur. Stand. (U.S.). Tech. Note 511. 24 pages (December 1969).

Key words: Carrier lifetime; germanium; lithium-drifted gamma-ray detectors; resistivity; resistivity inhomogeneities; second breakdown; silicon.

Work at NBS which led to the development of a broad program on Methods of Measurement for Semiconductor Materials. Process Control, and Devices is described. Initial work was concentrated on resistivity of silicon wafers and second breakdown in transistors. In the first case, the basis for a significant improvement in the method for measuring resistivity of silicon wafers was established, and in the second, concepts were developed which formed the basis of a new type of specification for operating conditions free from second breakdown. Work was extended to include other projects, including studies of germanium for gamma-ray detectors, carrier lifetime, and resistivity inhomogeneities which are still in progress. Formation of the broad program in response to increased interest in improved measurement methods is described.

TN512. **The accuracy of air tower pressure gages in suburban Washington, D.C.,** B. G. Simson and R. W. Radlinski, Nat. Bur. Stand. (U.S.), Tech. Note 512, 10 pages (Dec. 1969).

Key words: Air towers; tire pressure.

A survey of 50 air tower pressure gages in service stations of suburban Washington, D.C., was performed. Results showed that a motorist using these towers has only a 20 percent chance of inflating his tires within ±1 psi of the pressure indicated by the tower's gage. It is shown that a calibration of the tower gages would reduce the standard deviation of the obtained pressure to 0.5 psi.

TN513. **Hydrogen fluoride and the thermochemistry of fluorine,** G. T. Armstrong, Nat. Bur. Stand. (U.S.), Tech. Note 513, 21 pages (Feb. 1970).

Key words: Fluorides; fluorine dissociation energy; fluorine thermochemistry; heats of formation; hydrofluoric acid; hydrogen fluoride.

The thermochemistry of hydrogen fluoride is reviewed. The principal emphasis is on the experimental basis of the heats of formation of HF(g) and of HF(aq). Data from flame calorimetry in which HF(g) and HF(aq) are formed, evidence from processes involving other fluorine compounds, and some evidence from spectroscopic and photodissociation studies are brought together.

TN514. **ARPA-NBS program of research on high temperature materials and laser materials, January 1-June 30, 1969,** A. D. Franklin and H. S. Bennett, Editors, Nat. Bur. Stand. (U.S.), Tech. Note 514, 98 pages (Jan. 1970).

Key words: Band structure; chemical analysis; copper; creep; crystal defects; crystal growth; diffusion; evaporation; fracture; glass; high temperature materials; inhomogeneities in glass; laser damage; laser glass; lasers; mass transport; materials properties; mechanical relaxation; metal borides; optical properties; opto-elastic properties; oxides; polymers; ruby; titanium; transition.

Brief reviews are given of work performed during the period January 1 to June 30, 1969, on a number of projects concerned with High Temperature Materials and with Laser Materials. Under the High Temperature Materials heading, topics include diffusion of oxygen in oxides, growth of Al_2O_3 crystals by chemical vapor deposition, the electronic structure of transition metal borides and related compounds, the optical constants of titanium, high temperature creep in copper, fracture in glass, the mechanism of volatilization of polymers and long-chain compounds, and the interaction between mechanical relaxation and annealing in polymers. Work on Laser Materials includes measurement of bulk optical and elastic properties of laser materials, a study of the "orange" degradation of ruby, measurements of sub-crystal misalignment in ruby, damage in glass induced by high-energy laser pulses, chemical analyses for ruby and Nd-doped laser glasses, and preliminary studies on detection of submicroscopic inhomogeneities in glass.

TN515. **Use of an on-line computer in neutron time-of-flight measurements,** H. T. Heaton, II, Nat. Bur. Stand (U.S.), Tech. Note 515, 31 pages (Jan. 1970).

Key words: Data handling system; interruptable computer; neutron time-of-flight; neutron total cross section; on-line computer; Program Selector Board.

This paper describes the on-line data handling system at the NBS Electron Linear Accelerator facility as it is used for measuring neutron total cross sections by time-of-flight techniques.

TN516. **A selective roll-to-roll printer for producing duplicate microfilm copies, "Selectaframe" Printer,** J. N. Strohlein and T. C. Bagg, Nat. Bur. Stand. (U.S.), Tech. Note 516, 9 pages (Feb. 1970).

Key words: Information retrieval device; microcopier; microfilm duplicator; reader-printer; selective copier.

The "Selectaframe" printer, a convenient device for copying onto roll film selected frames from other rolls of film for subsequent automatic enlargement printing is described in detail.

TN517. **Accelerometer calibration with the earth's field dynamic calibrator,** J. S. Hilten, Nat. Bur. Stand. (U.S.), Tech. Note 517, 30 pages (Mar. 1970).

Key words: Accelerometer; air bearings; calibrator; accelerometer; dynamic; earth's field; interAgency transducer project; low frequency; rotational frequency response; transducer.

This paper describes a simple device for the precise dynamic calibration of certain accelerometers at low frequencies. Calibration of an accelerometer is achieved by rotating the instrument in the earth's gravitational field at a number of constant rotational speeds.

TN518. **Tabulation of data on semiconductor amplifiers and oscillators at microwave frequencies,** C. P. Marsden and R. Y. Cowan, Nat. Bur. Stand. (U.S.), Tech. Note 518, 66 pages (Feb. 1970)

Key words: Amplifiers; basic characteristics; microwave; oscillators; solid-state.

This tabulation includes some of the basic characteristics of semiconductor microwave devices, specifically amplifiers and oscillators of foreign and domestic origin.

TN519. **Forensic Science: A bibliography of activation analysis papers,** G. J. Lutz, Editor, Nat. Bur. Stand. (U.S), Tech. Note 519, 47 pages (Mar. 1970).

Key words: Activation analysis in forensic science; forensic science.

References to Activation Analysis in Forensic Science are indexed into 32 categories for precise literature searching by the Forensic Scientist. An Author index is included.

TN520. **Methods of measurement for semiconductor materials, process control, and devices, Quarterly Report, July 1 to September 30, 1969,** W. M. Bullis, Editor, Nat. Bur. Stand. (U.S.), Tech. Note 520, 69 pages (Mar. 1970).

Key words: Alpha detectors; aluminum wire; carrier lifetime; die attachment; electrical properties; epitaxial silicon; gamma detectors; germanium; gold-doped silicon; indium antimonide; metallization; methods of measurement; microelectronics; microwave devices; nuclear radiation detectors; resistivity; semiconductor devices; semiconductor materials; semiconductor process control; silicon; thermal resistance; thermographic measurements; ultrasonic microphone; wire bonds.

This quarterly progress report, fifth of a series, describes NBS activities directed toward the development of methods of measurement for semiconductor materials, process control, and devices. Principal emphasis is placed on measurement of resistivity, carrier lifetime, and electrical inhomogeneities in semiconductor crystals; evaluation of wire bonds; and measurement of thermal properties of semiconductor devices. Other tasks involve study of infrared measurement methods, deep-lying impurities in InSb, and gold in silicon; establishment of a processing facility; evaluation of aluminum metallization and wafer die attachment; review of NASA measurement methods; and measurement of Hall effect in semiconductor crystals, second breakdown in transistors, and properties of microwave devices. Related projects on silicon nuclear radiation detectors and specification of germanium are also described. Supplementary data concerning staff, committee activities, technical services, and publications are included as appendixes. Laboratory procedures for use and calibration of a capacitor microphone to measure vibration amplitude of the tool tip of an ultrasonic wire bonder are also described in a separate appendix.

TN521. **Present state of the classical theory of quantitative electron probe microanalysis,** K. F. J. Heinrich, Nat. Bur. Stand. (U.S.). Tech. Note 521, 17 pages (Aug. 1970).

Key words: Corrections; electron probe microanalysis; quantitative analysis; x-ray spectroscopy.

Although the foundations for a procedure of data reduction in quantitative electron probe analysis have not been changed for several years, there has been progress in the choice of expressions, parameters, and constants. A brief account of recommended expressions and procedures is given. Reference is made to the Standard Reference Materials of Au-Ag and Au-Cu alloys issued for electron probe microanalysis. These are especially useful for investigating the application of correction procedures.

TN522. **Beam handling techniques for electron linear accelerators,** S. Penner, Nat. Bur. Stand. (U.S.), Tech. Note 522, 21 pages (Apr. 1970).

Key words: Beam handling; beam optics; beam transport; electron linear accelerator; instrumentation for electron beams; linac.

The design of beam transport systems for electron linear accelerators intended for nuclear physics research is discussed. The subjects covered include beam optics, diagnostics and control of electron beams, and problems of handling high power beams.

TN523. **Experimental techniques for electron scattering investigations,** S. Penner, Nat. Bur. Stand. (U.S.), Tech. Note 523, 46 pages (Apr. 1970).

Key words: Background; current monitoring; detector ladders; electron scattering; experimental techniques; line-shape fitting; on-line computer systems; radiative tails; resolution; spectrometer design.

Modern experimental techniques for high energy electron scattering are discussed. Subjects included are: high resolution spectrometer design, the energy loss spectrometer concept, detector ladder systems, beam current monitoring techniques, suppression and measurement of background, the use of on-line computer systems, theoretical considerations and the analysis of data, and 180° scattering.

TN524. **Determination of the light elements in metals: A bibliography of activation analysis papers,** G. J. Lutz, Editor, Nat. Bur. Stand. (U.S.), Tech. Note 524, 70 pages (May 1970).

Key words: Boron; carbon; light elements; metals; nitrogen; oxygen; phosphorous; silicon; sulfur.

References to the Determination of the Light Elements in Metals using Activation Analysis are indexed according to the elements boron, carbon, nitrogen, oxygen, phosphorous, silicon and sulfur. The indexes are arranged by Element Determined and subdivided according to Matrices and Nuclear Reactions involved. An Author Index is included.

TN525. **The flammable fabrics program 1968-1969. U.S. Department of Commerce report of activities under the Flammable Fabrics Act 1968-1969,** Nat. Bur. Stand. (U.S.), Tech. Note 525, 84 pages (Apr. 1970).

Key words: Flammable fabrics; Flammable Fabrics Act of 1953; flammable fabrics program 1968-1969; reducing flammability; research authorized.

The 90th Congress amended the Flammable Fabrics Act of 1953 to authorize the Secretary of Commerce to conduct research on the flammability of fabrics, related materials, and products; to conduct studies on the feasibility of reducing their flammability; to develop test methods and devices; and to offer training in the use of these devices. In this publication, the National Bureau of Standards, to which responsibility for these activities was delegated, reports to Congress of the work done under this program from October 1968, when funds first were made available, to the end of 1969. Future reports will be issued annually.

The new action by Congress gives recognition to the fact that although many thousands of persons have been injured or killed as a result of the burning of flammable fabrics, adequate details have not been available on the causes of the accidents, the frequency of ignition of different kinds of garments and interior furnishings, the nature, extent, and severity of injury, and the nature of the hazards to which the public is exposed from burning fabrics. Much of the emphasis in the research summed up in this report has been on identifying these hazards and obtaining quantitative information about them. Some of the studies are being made by outside organizations, and these are reported as well as the in-house research at NBS.

TN526. **Tabulation of published data on electron devices of the U.S.S.R., through March 1970,** C. P. Marsden, Nat. Bur. Stand. (U.S.), Tech. Note 526, 122 pages (Oct. 1970).

Key words: Electron devices; electron tubes; semiconductors; U.S.S.R.

This tabulation includes published data on U.S.S.R. electron devices as collected from publications, mostly handbooks, published by the various ministries and institutes of the U.S.S.R. Information is given on all active devices ranging from receiving to microwave devices, semiconductor devices, and miscellaneous devices such as, for example, photographic flash tubes and thermistors.

TN527. **Methods of measurement for semiconductor materials, process control, and devices, Quarterly Report, October 1 to December 31, 1969,** W. M. Bullis, Editor, Nat. Bur. Stand. (U.S.), Tech. Note 527, 60 pages (May 1970).

Key words: Alpha detectors; aluminum wire; carrier lifetime; die attachment; electrical properties; epitaxial silicon; gamma detectors; germanium; gold-doped silicon; metallization; methods of measurement; microelectronics; microwave devices; nuclear radiation detectors; resistivity; semiconductor devices; semiconductor materials; semiconductor process control; silicon thermal resistance; thermographic measurements; ultrasonic bonder; wire bonds.

This quarterly progress report, sixth of a series, describes NBS activities directed toward the development of methods of measurement for semiconductor materials, process control, and devices. Principal emphasis is placed on measurement of resistivity, carrier lifetime, and electrical inhomogeneities in semiconductor crystals; evaluation of wire bonds, metallization adhesion, and die attachment; and measurement of thermal properties of semiconductor devices and electrical properties of microwave devices. Work on related projects on silicon nuclear radiation detectors and specification of germanium for gamma-ray detectors is also described. Supplementary data concerning staff, standards committee activities, technical services, and publications are included as appendixes.

TN528. **Tire use survey. The physical condition, use, and performance of passenger car tires in the United States of America,** J. L. Harvey and F. C. Brenner, Nat. Bur. Stand. (U.S.), Tech. Note 528, 59 pages (May 1970).

Key words: Accident; review; survey; tire disablement; tire inflation; tire loading; tire pressure gages; tire use; tread wear.

This review summarizes the results of two surveys of the physical condition and use of passenger car tires in the continental U.S.A., conducted under contract for the Office of Vehicle Systems Research (OVSR) of the National Bureau of Standards (NBS) during the period June 1967 through May 1968.

Data and results are compared with those in four related reports recently published by the Traffic Institute of Northwestern University. The latter reports cover studies on the use, condition, and performance of passenger car tires on the Illinois Tollway during the period September 1966 through August 1967. Pertinent information from various other sources is also included.

Based on the compiled evidence, some conclusions are drawn concerning the physical condition, use, and abuse of passenger car tires in service during these years, particularly with regard to tread depth, inflation pressures, and degree of overloading. The various estimates of tire disablement rates are compared, and contributions of tires to motor vehicle accidents explored.

The authors make several recommendations directed toward upgrading the level of quality of passenger car tires in service, and reducing their abuse, with the hope and expectation that service performance will be improved, and contributions of tires to highway accidents reduced.

TN529. **Determination of oxygen concentration in silicon and germanium by infrared absorption,** W. R. Thurber, Nat. Bur. Stand. (U.S.), Tech. Note 529, 21 pages (May 1970).

Key words: Absorption coefficient; infrared absorption; germanium; methods of measurement; oxygen in germanium; oxygen in silicon; silicon.

Infrared absorption measurements were made at room temperature, 80 K, and 20 K to determine the absorption coefficient of oxygen in silicon and germanium single crystals. A study was done to compare the results of four experimental methods, which involved both absolute and difference procedures. Sources of error were identified, including that due to calculating the absorption coefficient with an approximate equation which neglects multiple internal reflections. Measurements made on the same specimen at several temperatures give additional data on the relation of oxygen concentration to absorption coefficient at low temperatures.

TN530. **Systems analysis of inland consolidation centers for marine cargo,** R. H. Jordan, M. C. Stark, C. O. Bunn, J. L. Donaldson, W. J. Obright, H. R. Millie, J. Gilsinn, A. J. Goldman, W. A. Horn, Nat. Bur. Stand. (U.S.), Tech. Note 530, 162 pages (Nov. 1970).

Key words: Containerization; maritime, cargo; mathematical models; optimal locations; systems analysis; transportation.

This Technical Note documents a study, carried out for the U.S. Maritime Administration and completed by interested Bureau staff, to develop analytical techniques to optimize the locations and characteristics of inland consolidation centers for marine cargo. Such centers would consolidate less-than-container lots of cargo into "full" container loads for export, and would unload and distribute containerized import cargo.

After discussing the nature and scope of the study problem and outlining the functions and operations of the centers, the paper reports the fact-finding phase of the analysis. Successive chapters present and analyze data on: initial and operating costs for centers, current demand for their services as derived from a recent survey by the Delaware River Port Authority of its hinterland, and relevant (ground) transportation rates for containerized and uncontainerized material.

Reported next is the development of a mathematical model for estimating good locations and sizes for the consolidation centers. The selective implementation of this model as a computer program is described in sufficient detail to guide prospective users. A final chapter describes the illustrative application of this program to the data at hand, with results quite encouraging for the "inland center" concept.

TN531. **ARPA-NBS program of research on high temperature materials and laser materials, Reporting Period 1 July to 31 Dec., 1969,** High Temperature Materials Reports edited by A. D. Franklin, Laser Materials Reports edited by H. S. Bennett, Nat. Bur. Stand. (U.S.), Tech. Note 531, 75 pages (June 1970).

Key words: Band structure; chemical analysis; copper; creep; crystal defects; crystal growth; diffusion; evaporation; glass; high temperature materials; inhomogeneities in glass; laser damage; laser glass; lasers; mass transport; materials properties; metal properties; optical properties; opto-elastic properties; oxides; polymers; ruby; titanium; transition.

Brief reviews are given of work performed during the period July 1 to December 31, 1969, on a number of projects concerned with High Temperature Materials and with Laser Materials. Under the High Temperature Materials heading, topics include diffusion of oxygen in oxides, growth of Al_2O_3 crystals by chemical vapor deposition, the electronic structure of transition metal borides and related compounds, the optical constants of titanium, high temperature creep in copper, and the mechanism of volatilization of polymers and long-chain compounds. Work on Laser Materials includes measurement of bulk optical and elastic properties of laser materials, a study of the "orange" degradation of ruby, measurements of sub-crystal misalignment in ruby, damage in glass induced by high-energy laser pulses, chemical analyses for ruby and Nd-doped laser glasses, and preliminary studies on detection of submicroscopic inhomogeneities in glass.

TN532. **Pollution analysis: A bibliography of the literature of activation analysis,** G. J. Lutz, Editor, Nat. Bur. Stand. (U.S.), Tech. Note 532, 32 pages (June 1970).

Key words: Activation analysis; element determined; matrix analyzed; pollution analysis; technique used.

The literature of the use of activation analysis of pollution samples is reindexed in detail with respect to Element Determined, Matrix Analyzed and Technique Used for precise literature searching. An author index is included.

TN533. **14-MeV neutron generators in activation analysis: A bibliography,** G. J. Lutz, Editor, Nat. Bur. Stand. (U.S.), Tech. Note 533, 91 pages (June 1970).

Key words: Activation analysis; element determined; matrix analyzed; technique used; 14-MeV neutron generators.

The literature of 14-MeV neutron generators in activation analysis is reindexed in detail with respect to Element Determined, Matrix Analyzed and Technique Used for precise literature searching. An author index is included.

TN534. **Oceanography: A bibliography of selected activation analysis literature,** G. J. Lutz, Editor, Nat. Bur. Stand. (U.S.), Tech. Note 534, 36 pages (June 1970).

Key words: Activation analysis; element determined; matrix analyzed; oceanography; technique used.

The literature of oceanography in activation analysis is reindexed in detail with respect to Element Determined, Matrix Analyzed and Technique Used for precise literature searching. An author index is included.

TN535. **Compilation and use of criminal court data in relation to pre-trial release of defendants. Pilot study,** J. W. Locke, R. Penn, J. Rick, E. Bunten, and G. Hare, Nat. Bur. Stand. (U.S.), Tech. Note 535, 242 pages (Aug. 1970).

Key words: Bail; criminal court data; criminal justice system; dangerousness; data collection problems and procedures; District of Columbia; judicial system; prediction research; pre-trial release; preventive detention; recidivism; statistical relationships.

A number of Pre-Trial Release studies which have been conducted during the past several years show that various measures of criminal activity while on release vary from 7.9 percent (reindictment for those indicted on felony charges) to 70 percent (re-arrest of those originally arrested on a robbery charge). Little actual sentence data were available for or presented in these studies, and no personal data on the defendants or facts about the crimes themselves were shown. This document describes a pilot study of a very thorough analysis of criminal cases, including both felonies and misdemeanors, in a four week sample of cases in the District of Columbia during the first half of 1968. The method of data collection is described, together with attendant problems. Possible techniques of data presentation are shown along with criteria and relevant factors pertinent in quantifying "dangerousness." The potential for developing "dangerousness" prediction methods as a basis for decisions on pre-trial release is analyzed, with the conclusion that much work needs to be done before an effective prediction device based on a "dangerousness" criterion can be formulated.

Summary data for 712 defendants in a sample of 4 weeks taken from the first half of 1968 are presented. Comparisons are made to show the re-arrest rates for defendants initially charged with particular classes of crime. Personal characteristics are examined to determine if any are significant predictors of recidivism. A recidivism index is formulated to give the rate of re-arrest per man-day of exposure. Robbery cases are examined in more detail.

TN536. **Disclosures on: Viscous damped wind vane; nonskid road or runway; regrooved pneumatic tire with removal inserts; device for radially positioning a rotating wheel; method for fabricating precision waveguide sections; distortion-cancelling loudspeaker system; cryogenic fluid density measurement system; and controlled-atmosphere weathering device,** D. Robbins and A. J. Englert, Editors, Nat. Bur. Stand. (U.S.), Tech. Note 536, 25 pages (June 1970).

Key words: Acclerated weathering test; acoustic distortion, cancelling; averaging wind vane; cryogen density, measuring; distortion-cancelling loudspeakers; grooved runway; hydroplaning skidding, prevention of; loudspeaker system; photoactivated weathering test; radial positioning, wheel on shaft; rubber-surfaced road; slush cryogen density; tire groove insert; tire regrooving; waveguide, precision fabrication; waveguide, adjustable width; weathering test; wheel-shaft angle, shifting during rotation; wind vane, damped.

This Note describes and illustrates eight developments that are believed to embody interesting and unusual solutions to current problems in their fields.

TN537. **Nomographs for use in the fabrication and testing of Ge(Li) detectors,** A. H. Sher, Nat. Bur. Stand. (U.S.), Tech. Note 537, 18 pages (Aug. 1970).

Key words: Capacitance; detector resolution; effective Fano factor; Ge(Li) detector; lithium-ion drift; nomograph; oxygen concentration.

Six nomographs which can facilitate the fabrication and testing of lithium-drifted germanium gamma-ray detectors [Ge(Li) detectors] have been constructed which relate the following parameters: (1) time, temperature, applied bias, and drifted depth; (2) lithium mobility, crystal resistivity, and oxygen concentration; (3) area, capacitance, and drifted depth for planar Ge(Li) detectors; (4) drifted depth, length, and capacitance for coaxial Ge(Li) detectors; (5) total spectral resolution, system noise, and detector resolution; and, (6) detector resolution, gamma-ray energy, and effective Fano factor. The use of these nomographs is described and illustrative examples are given.

TN538. **Automated fingerprint identification,** J. H. Wegstein, Nat. Bur. Stand. (U.S.), Tech. Note 538, 33 pages (Aug. 1970).

Key words: Computerized-fingerprint-identification; fingerprint; pattern recognition.

A procedure is described for determining whether two fingerprint impressions were made by the same finger. The procedure uses the x and y coordinates and the individaul directions of the minutiae (ridge endings and bifurcations). The identity of two impressions is established by computing the density of clusters of points in $\Delta x - \Delta y$ space where Δx and Δy are the differences in coordinates that are found in going from one of the fingerprint impressions to the other. Experimental results using machine-read minutiae data are given along with results from a previously reported procedure that utilized constellations of minutiae in its matching process.

TN539. **Improvements in oscilloscopic measurements in high-speed experiments,** A. Cezairliyan, M. S. Morse, and H. A. Berman, Nat. Bur. Stand. (U.S.), Tech. Note 539, 20 pages (Oct. 1970).

Key words: High-speed measurements; high-speed recording; oscilloscopes.

Two refinements in oscilloscopic recording have been made which improve considerably the recording of isolated events in heavy current discharge studies, where substantially rectangular pulses are employed. The accuracy of the method employed has been verified experimentally to be in the region of 0.01 to 0.1 percent. The first refinement is a unit for the differential suppression of the incoming signal by an adjustable amount, and the second refinement is a system by which time markers are sent to several oscilloscopes at adjustable time intervals simultaneously with the actual incoming signal.

TN542. **Activities of the NBS spectrochemical analysis section July 1969 to June 1970,** B. F. Scribner, Editor, Nat. Bur. Stand. (U.S.), Tech. Note 542, 114 pages (Nov. 1970).

Key words: Analysis; computer program; electron probe; microanalysis; optical spectrometry; pre-concentration techniques; spectrochemical analysis; standard reference materials; x-ray fluorescence analysis.

Spectrochemical research activities, improvements in equipment, and applications, especially to the certification of NBS Standard Reference Materials, are summarized. In electron probe microanalysis, a comprehensive computer correction program for accurate analysis of materials relative to single elements or simple compounds was developed, an improved lithium-doped silicon detector was found to provide increased resolution, and improvements in microprobe instrumentation produced a high level of stability. Studies of procedures for correction of x-ray fluorescence measurements were made, instrumental changes resulted in marked improvement in performance reliability, and new applications were made. In optical emission spectrometry, studies were made of beryllium determination in an air pollution investigation and trace analyses were made of organic materials to parts per billion (10^{-9}) limits. Methods of pre-concentration of impurities are described for optical emission and isotope dilution spark source mass spectrometric analysis of ingot iron, botanical materials, and high purity reagents. Work on Standard Reference Materials resulted in certification of stainless steel, clays, ferrosilicon, blast furnace irons, white irons, lead bearing metal, and ductile irons. Listings are given of 18 publications and 28 talks by members of the Section during the year.

TN543. **Electrochemical analysis section: Summary of activities July 1969 to June 1970,** R. A. Durst, Editor, Nat. Bur. Stand. (U.S.), Tech. Note 543, 92 pages (Nov. 1970).

Key words: Acidity; conductivity; coulometric analysis; electrochemical analysis; ionic activity; ion-selective electrodes; pH measurements; potentiometry; standard reference materials.

This survey of the activities of the Electrochemical Analysis Section, Analytical Chemistry Division, covers the period from July 1969 to June 1970. An attempt is made to briefly summarize a year's progress on the technical projects of the Section, to indicate the composition and capabilities of the unit as a whole, and to stress the Section's role in the mission of the Institute. Summaries of the work in each of the Section competences are given. In the area of acidity measurements, work continued on the standardization of tris(hydroxymethyl)aminomethane for use as a biologic pH buffer material and standard for clinical pH measurements. Progress toward reference standards for the calibration of ion-selective electrodes is reported including pM and pCl values for both NaCl and KCl. A study using the silver sulfide ion-selective electrode for measuring trace silver ion losses due to adsorption on selected surfaces is described. High-precision coulometry is used to determine the atomic weight of zinc, the purity of EDTA, and the stoichiometry of gallium arsenide.

TN544. **Analytical coordination chemistry section: Summary of activities, July 1969 to June 1970,** O. Menis and J. I. Shultz, Editors, Nat. Bur. Stand. (U.S.), Tech. Note 544, 151 pages (Sept. 1970).

Key words: Bilirubin solvent extraction with β-isopropyltropolone; clinical; filter; fluorimetric standards; inert gas fusion; lead-base alloys; multi-element flame spectrometer; spectrophotometric standards; steels and metallo-organics; thermal analysis DTA Standards; trace elements-glass standards.

Progress in research and development in several areas of analytical chemistry, as related to the Standard Reference Materials program is described. Based on the need for spectrophotometric standards by clinical chemists, both solid and liquid filters for calibrating the photometric scale are being developed. Similar needs and plans are reviewed for fluorimetric quantum yield standards. Development of flame spectrometry instruments are described which include a high precision multi-element flame spectrometer for simultaneous atomic absorption and flame emission, a ratio recording double beam spectrometer, new burner designs and the evaluation of a hollow cathode designed by Grimm. The multichannel spectrometer provides for the simultaneous determination of elements such as Na, K, Ca, CaOH and Mg with Li as the internal standard, and a seventh position for background of wavelength scan, and a digital system with tape for computer calculations.

The beginning of a comprehensive study of the absorbing and non-absorbing lines in atomic absorption is presented. Description is given of homogeneity studies and the analysis of glass standards containing 60 elements at the 0.2 to 500 ppm level with a relative standard deviation of 1-2 percent. Gold, iron, manganese, nickel, potassium, rubidium and strontium were determined, without prior chemical separations by spectrophotometric or atomic absorption and flame emission methods. A precise method for the flame emission determination of aluminum in ferrous materials by derivative optical scanning is also described.

Solution complexation studies involve the reactions of metals with bilirubin and the evaluation of equilibrium constants and kinetics in solvent extraction of iron and vanadium with β-isopropyltropolone.

In the area of thermal analysis, provisional certification of potassium nitrate (SRM 756) and quartz (SRM 755) for temperature scale DTA standards, and the studies of sulfur, stearic acid and hexachloroethane for the lower temperature scale are reported. For gases in metals, improvements in inert gas fusion analysis involved instrumental modifications which permitted sample changes in less than 12 seconds. Finally, the characterization of the following Standard Reference Materials are discussed: lead-bearing alloys, SRM 53e and 1132; carbon steel, SRM 20g; stainless steel, SRM 101f; low-carbon stainless steel, SRM 166c; metallo-organic, SRM 1061c, special steels, SRM 361, 362 and 365.

TN545. **Microchemical analysis section: Summary of activities July 1969 to June 1970,** J. K. Taylor, Editor, Nat. Bur. Stand. (U.S.), Tech. Note 545, 126 pages (Dec. 1970).

Key words: Air pollutant analysis; chemical analysis; gas analysis; microchemical analysis; microscopic analysis; polarographic analysis.

This report describes the research activities and scientific programs of the Microchemical Analysis Section of the Analytical Chemistry Division of the National Bureau of Standards, Institute for Materials Research during the period July 1969 to June 1970. General Activities are reviewed in areas of gas analysis polarography, chemical microscopy, and classical microchemical analysis. Research activities described in some detail include: preparation and analysis of carbon monoxide mixture for standard reference materials; evaluation of sulfur dioxide permeation tubes as analytical standards; polarographic methods for determination of trace elements in a number of materials; certification of urea as a microchemical standard. A chapter reviewing the state-of-the-art of analysis for air pollutants is also included.

TN 546. **Analytical Mass Spectrometry Section: Summary of activities, July 1969 to June 1970,** W. R. Shields, Editor, Nat. Bur. Stand. (U.S.), Tech. Note 546, 120 pages (Nov. 1970).

Key words: Instrumentation; isotopic analysis; mass spectrometry; procedures.

This report describes the advances in instrumentation and the research activities of the Analytical Mass Spectrometry Section during the period July 1969 to June 1970.

Advances in instrumentation include the construction of a computer controlled mass spectrometer with appropriate interconnecting components, power supplies with greatly increased stability and the utilization of a magnetic field control.

Elements studied during this period include: B, Cu, Ag, Pb, Tl, U, Pu, K, Rb, Ni and Mo. Chemical procedures are given for Cu, Ag, Pg, Tl, U, K, Rb, Ni and Mo. Mass spectrometric procedures are given for Pb, Tl, U, K, Ni and Mo. Chemical procedures for the intercomparison of redox standards are also given.

TN547. **Organic chemistry section: Summary of activities July 1969 to June 1970,** R. Schaffer, Editor, Nat. Bur. Stand. (U.S.), Tech. Note 547, 134 pages (Nov. 1970).

Key words: "Azobilirubin"; bilirubin; β-NAD; β-NADH; cholesterol; cortisol; D-mannitol; electron spin resonance; proton magnetic resonance; skew conformations; standard reference materials; uric acid; VMA.

This report of the Organic Chemistry Section of the National Bureau of Standard's Institute for Materials Research provides a summary of a year's scientific activity; as such, it covers both work that was completed and some that is still in progress. The development of Standard Reference Materials (SRMs) and their certification constitute a significant output that we term the sample aspect of our programs. The research component appears in the form of journal publications.

About one-half of the report concerns SRMs. Spectrophotometric measurements of bilirubin and of "azobilirubin" in simple solvents and in serum or proteins are given much attention. D-Glucose for use as a clinical standard is examined by gas-liquid chromatography and differential scanning calorimetry to ascertain changes in the proportions of the anomeric forms of the sugar during these measurements. Additional compounds for development as SRMs are cortisol, 4-hydroxy-3-methoxy-DL-mandelic acid (VMA), D-mannitol, and the reduced form of β-NAD. Some properties thus far studied on commercially available specimens are reported.

In carbohydrate research programs, the purity of 1,2:4,5-di-*O*-isopropylidene-D-fructose and the importance of using it pure for conversion into pure D-psicose are described. The proton magnetic parameters of the unquestioned, skew conformation of 3-*O*-benzoyl-1,2,4-*O*-benzylidyne-α-D-ribopyranose are analyzed. These parameters have major utility as a model for conformational analysis. Iterative analysis of p.m.r. spectra and the conformations of some D-glucose derivatives are described. Also, work is reported on cyclic polyhydroxy compounds, including oxidation, electron spin resonance, and new derivatives.

Finally, a number of other topics are described: iodination of β-diketones with periodic acid, and reactions of bilirubin, hemin, and related bile pigments; also, some work on the detection of polynitro aromatic compounds is given.

TN548. **Activation Analysis Section: Summary of activities, July 1969 to June 1970,** P. D. LaFleur and D. A. Becker, Editors, Nat. Bur. Stand. (U.S.), Tech. Notes 548, 164 pages (Dec. 1970).

Key words: Activation analysis; Cockcroft-Walton neutron generator; computer programming; NBS LINAC; NBS reactor; standard reference materials.

This survey of the activities of the Activation Analysis Section covers the period July 1969 to June 1970. An overview of the progress made by the various projects in the Section is given. A discussion of the operating characteristics of the NBS Reactor for activation analysis is given and the research activities of the various projects are discussed. Special attention is given to the many practical problems encountered by the Section during the year, and the results of the solutions to these problems, especially the analysis of Trace Elements in Glass Standard Reference Material (SRM) and of the botanical SRM. The quantitative analysis for boron using the nuclear track technique is discussed as well as extension of the analysis for uranium using this technique.

An extensive discussion of the value of 3-MeV neutrons in neutron generator activation analysis and the experimental parameters for using these neutrons is discussed. The new target and pneumatic transfer systems at the NBS LINAC for photon activation analysis are described and the application of photon activation analysis for determining thallium in glass and high purity metals and gold, manganese and iron in high purity cadmium is discussed. Research into determination of nitrogen by photon activation analysis is described.

A computer program, ALSPIS, for peak finding and integration is described and the application of a mini-computer to the Activation Analysis Section is noted.

TN550. **A systems programmer's guide for implementing OMNITAB II,** S. T. Peavy, R. N. Varner, and S. G. Bremer, Nat. Bur. Stand. (U.S.), Tech. Note 550, 43 pages (Nov. 1970).

Key words: ANSI FORTRAN; double precision; general-purpose computer program; implementation of OMNITAB II; labeled common; machine independent; OMNITAB II; overlay; segmentation; system parameters; transportable computer programs.

OMNITAB II is a general-purpose program which permits direct use of a computer without prior knowledge of computer languages. Every effort has been made to produce a system as machine independent as possible to make implementation of any large computer configuration relatively easy. However, there are a few modifications which may have to be made.

This Technical Note provides assistance to the systems programmer, with the task of implementing OMNITAB II, by pointing out where difficulties may occur and how to cope with them. It furthermore outlines a method for segmenting the OMNITAB II system which is very large. It is a partial documentation of the OMNITAB program.

OMNITAB II is a large system requiring a large computer. Overlay and segmentation are virtually essential. A method for segmenting OMNITAB II is outlined. The method should be useful for many computers.

TN553. **Critical evaluation of data in the physical sciences—a status report on the National Standard Reference data system, June 1970,** D. R. Lide, Jr., Editor, Nat. Bur. Stand. (U.S.), Tech. Note 553, 77 pages (Sept. 1970).

Key words: Atomic and molecular data; chemical kinetics; colloid and surface properties; data systems design; information services; mechanical properties; nuclear data; standard reference data; solid state data; thermodynamic and transport properties.

This is a report on the status of the National Standard Reference Data System as of June 1970. Recent activities of the Office of Standard Reference Data are summarized and future plans are indicated. A complete list of data evaluation projects supported by the Office of Standard Reference Data during Fiscal Year 1970 is included. Progress in data processing and in information services is reviewed. The appendix includes a listing of continuing data centers in the United States and a list of publications resulting from the standard reference data program.

TN554. **Annotated accession list of data compilations of the NBS Office of Standard Reference Data,** H. M. Weisman and G. B. Sherwood, Nat. Bur. Stand. (U.S.), Tech. Note 554, 196 pages (Sept. 1970).

Key words: Accession list; atomic and molecular properties; chemical kinetics; colloid and surface properties; fundamental particles properties; general collections; mechanical properties; nuclear properties; solid state properties; thermodynamic and transport properties.

The National Bureau of Standards, Office of Standard Reference Data has attempted to acquire all significant reference data compilations on a worldwide basis. This publication lists the collection of documents so acquired, together with their abstracts. The documents are organized in the following categories: General Collections, Nuclear Properties (including Fundamental Particles Properties), Atomic and Molecular Properties, Solid State Properties, Chemical Kinetics, Colloid and Surface Properties, Mechanical Properties, and Thermodynamic and Transport Properties. Sources of availability for the listed publications are also provided.

TN555. **Methods of measurement for semiconductor materials, process control, and devices, Quarterly Report, January 1 to March 31, 1970,** W. M. Bullis and A. J. Baroody, Jr., Editors, Nat. Bur. Stand. (U.S.), Tech. Note 555, 63 pages (Sept. 1970).

Key words: Alpha-particle detectors; aluminum wire; carrier lifetime; die attachment; electrical properties; epitaxial silicon; gamma-ray detectors; germanium; gold-doped silicon; metallization; methods of measurement; microelectronics; microwave devices; nuclear radiation detectors; resistivity; semiconductor devices; semiconductor materials; semiconductor process control; silicon; thermal resistance; thermographic measurements; ultrasonic bonder; wire bonds.

This quarterly progress report, seventh of a series, describes NBS activities directed toward the development of methods of measurement for semiconductor materials, process control, and devices. Principal emphasis is placed on measurement of resistivity, carrier lifetime, and electrical inhomogeneities in semiconductor crystals; evaluation of wire bonds, metallization adhesion, and die attachment; and measurement of thermal properties of semiconductor devices and electrical properties of microwave devices. Work on related projects on silicon nuclear radiation detectors and specification of germanium for gamma-ray detectors is also described. Supplementary data concerning staff, standards committee activities, technical services, and publications are included as appendixes.

TN556. **Development and current status of the standard nuclear instrument module (NIM) system,** L. Costrell, Nat. Bur. Stand. (U.S.), Tech. Note 556, 15 pages (October 1970).

Key words: Instrumentation; instruments; modules; nuclear; standards, NIM.

The standard Nuclear Instrument Module (NIM) system described in AEC Report TID-20893 is widely used in laboratories throughout the world. This report presents a history of the development and reviews the current status of the NIM system.

TN557. **The brake pedal force capability of adult females,** R. W. Radlinski and J. I. Price, Nat. Bur. Stand. (U.S.), Tech. Note 557, 25 pages (Oct. 1970).

Key words: Automotive braking systems; brakes; brake pedal forces; Federal Motor Vehicle Safety Standards; pedal effort; women, strength of.

A survey of the brake pedal force capability of 105 women employees at the National Bureau of Standards, Washington, D.C., was performed utilizing two stationary passenger automobiles as test vehicles. Results showed that over 50% of the test subjects could not achieve an average sustained brake pedal force of 200 lb, a value which is considered an acceptable braking system input force under certain conditions of the current Federal Motor Vehicle Safety Standard (FMVSS No. 105) for passenger vehicle braking system performance.

3.13. CONSUMER INFORMATION SERIES

Practical information, based on NBS research and experience, covering areas of interest to the consumer. Easily understandable language and illustrations provide useful background knowledge for shopping in today's technological marketplace.

CIS1. **Fibers and fabrics,** J. M. Blandord, Nat. Bur. Stand. (U.S.), Consumer Info. Series 1, 31 pages (Nov. 1970).

Key words: Apparel, textile; blends, fabric; care instructions, textiles; consumer goods, textile; fabrics, textile; fibers, textile; flammability, textile; glossary, textile; properties, textile fiber; textiles; wash-and-wear textiles.

Fibers and fabrics is especially designed for the consumer who purchases and cares for fabrics, apparel, home furnishings, and household textile products. It characterizes the properties, methods of care, and major uses of the consumer textile products in the United States. Included in the booklet are sections on fabric blends, wash-and-wear textiles, and a glossary of commonly-used textile terms.

CIS2. **Tires, their selection and care,** A. Brenner, Nat. Bur. Stand. (U.S.), Consumer Info. Series 2, 32 pages (Nov. 1970).

Key words: Construction; maintenance; passenger car tires; safety; tires, passenger car; wear.

The booklet provides the information needed to obtain maximum safety, wear, and performance from tires. It discusses such factors as matching the tire to driving habits, types of roads normally driven, and loads to be carried. Also covered are proper tire maintenance, and the relationship among driving habits, tire wear, and safety.

CIS3. **Adhesives for everyday use,** K. F. Plitt, Nat. Bur. Stand. (U.S.), Consumer Info. Series 3, 17 pages (Nov. 1970).

Key words: Adhesion; adhesive properties; adhesive selection; adhesives, bonding; surface preparation.

This publication is intended to assist the consumer in selecting and using adhesives for ordinary applications. It covers the type of adhesives generally available in retail stores and points out the major features of each type.

4. TITLES AND ABSTRACTS OF PAPERS PUBLISHED BY OTHERS, 1970

Reprints from the journals listed in this section may often be obtained directly from the authors. See page — for additional information.

10863. Carter, G. C., **The NBS Alloy Data Center,** *Mater. Res. Bull.* **3,** 919-922 (1968).

Key words: Alloys; automated; bibliography; data; files; indexing computer programs; information; metals; physical properties; reference books (material).

A summary of the detailed description of the Alloy Data Center is presented.

10864. Case, W. E., Harrington, R. D., **Hysteresis effects in the slope calibration method for magnetometers,** *Proc. IEEE* **56,** No. 10, 1733-1734 (Oct. 1968).

Key words: Magnetization; magnetometer calibration; vibrating-sample magnetometer.

The slope method for calibrating vibrating sample magnetometers requires spherical samples of high permeability such that

$$(\mu+2)/(\mu-1)\approx 1.$$

It is shown that the presence of a small remanence in the calibration spheres results in an effective permeability that is as great if not greater than the initial permeability which is often used in the above equation. This even higher permeability further increases the validity of this approximation.

10865. Casella, R. C., **Decay modes with coherent resonant-energy transfer between deep impurities in solids,** *Phys. Rev.* **174,** No. 3, 830-834 (Oct. 15, 1968).

Key words: Coherence; decay modes; impurities; resonant-energy transfer.

Attention is called to the existence of new decay modes for deep impurities in solids associated with coherence in the resonant-energy transfer between them. The theoretical decay rate R of the two-impurity complex is of the form, $R(t) = C_1 \exp(-\gamma_1 t)+C_2 \exp(-\gamma_2 t)+\exp[-1/2 (\gamma_1+\gamma_2)t]\times \mathrm{Re}\, D \exp(-i\Delta t)$, with C_n and γ_n real positive and D complex. The oscillations in time, t exhibited by the third term in the expression for R provide an experimental test for the coherence effect. The partial rate $R_r(t)$ for radiative decay is of the same form as R(t). In the analysis, use is made of an analogy between the decay of the excited impurity complex and that of K° mesons in particle physics, where similar coherent oscillations have been observed experimentally.

10866. Casella, R. C., **Time reversal and the K° meson decays. I,** *Phys. Rev. Letters* **21,** No. 15, 1128-1131 (Oct. 7, 1968).

Key words: Decay rates; symmetry; TCP; time reversal.

Based upon present data, we show that time reversal symmetry is violated, independently of how the vital question concerning possible TCP asymmetry is ultimately resolved.

10867. Casella, R. C., **Time reversal and the K° meson decays. II,** *Phys. Rev. Letters* **22,** No. 11, 554-556 (Mar. 17, 1969).

Key words: CPT theorem; decays; mesons; time reversal; weak interactions.

Current data on the $K^\circ \to 2\pi$ decays are used to extend the results of an earlier analysis testing these reactions for T invariance irrespective of CPT symmetry. The extended analysis together with recent work on pion production data allow us to establish that T is not conserved in these decays.

10868. Cassel, J. M., Gallagher, J., Reynolds, J. A., Steinhardt, J., **The role of transport ion binding studies of serum albumin,** *Biochemistry* **8,** No. 4, 1706-1713 (Apr. 1969).

Key words: Albumin; binding; detergent; dialysis; kinetic anomalies in dialysis; long-chain ligands; protein concentration effects.

Two hypotheses previously suggested to explain the apparent dependency on protein concentration of equilibrium dialysis measured binding of long-chain ionic ligands to bovine serum albumin have been tested and disproved. Of greater importance, it is shown that the apparent protein concentration effect was an experimental artifact which originated in the anomalously slow approach to equilibrium with these ligands under the conditions of the earlier experiments. The effects of protein concentration, ligand size, supporting electrolyte and temperature on the approach to dialysis equilibrium is examined. Hitherto unobserved and only partially understood kinetic anomalies occur when ionic ligands of high affinity are dialyzed *into* protein solutions which are appreciably more concentrated than 0.1 percent.

10869. Cassel, J. M., Steinhardt, J., **Limitations inherent in the ΔpH method of determining binding isotherms of bovine serum albumin,** *Biochemistry* **8,** No. 6, 2603-2609 (June 1969).

Key words: Anion binding; anionic detergents; bovine serum albumin; electrostatic interaction factor; equilibrium dialysis; hydrophobic interaction; permselective membrane; Scatchard-Black method.

Binding isotherms, determined by the ΔpH method of Scatchard and Black, of a large variety of aliphatic and aromatic anions, containing up to 14 carbon atoms, have been compared with isotherms obtained with the same substances by equilibrium dialysis and in two instances by measurement of potentials across permselective membranes. With symmetric non-deformable ions e.g., aromatic anions, the ΔpH method gives results in good agreement with those determined by dialysis. With aliphatic long chain anions, the amount of binding and the binding constants are systematically underestimated by factors which increase with the affinity. In these comparisons due regard has been taken of (a) the effects of the necessary differences in the amounts of competing electrolyte present when each of the three methods is used, and (b) need to correct for the lack of buffering capacity in very dilute solutions of unbuffered protein. Two methods for evaluation of an empirical electrostatic factor ω from the ΔpH binding measurements in 0.001 M NaCl are discussed. Explanation of the much lower ω so computed from that calculated by application of Debye-Hückel theory is sought in terms of applicability of the Linderström-Lang model to noncovalently bound long chain ions with hydrophobic tails and of differences between the effective charge Z of the macroion and the charge computed stoichiometrically. It is shown that as a practical matter the ΔpH method cannot be applied to any ligand of high affinity ($K > 10^5$) because of the large effect in this method of small errors in determining concentration or protein molecular weight.

10870. Cassidy, E. C., Abramowitz, S., **Time-resolved emission and absorption studies of exploding wire spectra,** (Proc. 4th Conf. Exploding Wires, Boston, Mass., Oct. 18-21, 1967), Chapter in *Exploding Wires* **4,** 109-124 (Plenum Press Inc., New York, N.Y., 1968).

Key words: AlO; electrical discharges; exploding wire; time-resolved spectroscopy; TiO.

Emission and absorption studies of the spectra produced by exploding wires in oxygen, nitrogen, hydrogen, or argon atmospheres are described. A drum camera and a rotating shutter are used for continuous and time-resolved recording of the explosion spectra. A high-intensity light source (a second exploding wire or Lyman flashtube), synchronized with the rotating shutter, is flashed through the explosion vapor for the absorption studies. Results from experiments performed under a variety of controlled conditions are presented. Effects of environment, pressure, and electrical energy on the spectrum are discussed, and conditions found conducive to production of selected features are indicated. The exploding wire is shown to be a rich source for study of the AlO molecule, and observation of a number of new bands (believed to be part of the $B\,^2\Pi_i - X\,^2\Sigma^+$ transition) is reported. Preliminary experiments with titanium wires exploded in oxygen suggest that the exploding wire may also be a desirable source for spectral studies of the TiO molecule. Some results from this work are included.

10871. Cassidy, E. C., Cones, H. N., Wunsch, D. C., Booker, S. R., **Calibration of a Kerr cell system for high-voltage pulse measurements,** *IEEE Trans. Instr. Meas.* **IM-17,** No. 4, 313-320 (Dec. 1968).

Key words: Electro-optical measurements; high voltage measurements; Kerr cell; pulse measurements.

Several techniques for calibration of an electro-optical (Kerr cell) high voltage pulse measuring system are described. Independent calibrations, without reference to pulse divider measurements, are achieved by application of a direct bias voltage to the Kerr cell. After calibration, experiments with voltages as high as 100 kV demonstrate reasonable agreement (to within 1 percent) between simultaneous Kerr cell and calibrated pulse divider measurements.

10872. Chang, S. S., **Switch arrangement and power averaging in constant current calorimetric heating,** *Rev. Sci. Instr.* **40,** 822-825 (1969).

Key words: Calorimetry; constant current power supply; energy measurement; power averaging; switch contact arrangement; transient.

In order to minimize the transient effect associated with switching a constant current power supply to different loads, a break-before-make type of switch contact arrangement is shown to be preferable to a make-before-break type of arrangement. Series resistance in the load circuit may be required for low current applications.

With a constant heater current, the average heater power for the entire heating period can be precisely determined as the product of the current and the mean value of two particular potential readings. These two readings, symmetrical about the mid-point of the heating period, should be taken at specified intervals as determined by the exponential heat conduction characteristics of the calorimeter assembly.

10873. Christ, B. W., Giles, P. M., **On the detection of retained austenite in high-carbon steels by Fe^{57} Mössbauer spectroscopy, with appendix,** *Trans. Met. Soc. AIME* **242,** 1915-1925 (Sept. 1968).

Key words: Chemical shift; hyperfine peaks; Mössbauer spectra; retained austenite; singlet center peak; x-rays; 10105 steel.

Mössbauer effect measurements have been made on 1-mil-thick foils of commercial 1 wt pct C steel and Fe-2 wt. pct C alloy. The experimental method required about 3 to 5 vol pct of a phase in the multiphase steel sample for detection. Room-temperature Mössbauer patterns obtained on austenitized and quenched samples exhibit fifteen, and possibly twenty-one, lines. A sharp paramagnetic singlet and a quadrupole doublet, poorly resolved from the singlet, are attributed to austenite. Remaining lines are due to martensite. Accurate evaluation of austenite line parameters is not feasible if significant amounts of other phases such as carbides or martensite occur simultaneously with austenite. This is demonstrated by comparison of hyperfine interactions determined for austenite in multiphase high-carbon samples with those reported for Fe–C austenite in a nearly 100 pct austenitic sample. Lines from carbides are incompletely resolved from austenite lines, as demonstrated by comparison of austenite line positions with carbide line positions calculated from published values of hyperfine interactions. One martensite line overlaps an austenite line in the pattern for commercial 1 wt pct C steel. Results of this study suggest that the usefulness of Fe^{57} Mössbauer spectroscopy for quantitative analysis of austenite in bulk samples of quenched and tempered high-carbon steels is restricted by poor resolution. Use of Mössbauer spectroscopy for phase identification and for evaluation of atomic and electronic structures appears quite feasible.

10874. Christ, B. W., Smith, G. V., **Effects of impurities on yield and flow strength of zone refined iron,** *Mem. Sci. Rev. Met.* LXV, 208-223 (June 15, 1968).

Key words: Alloys; dilute, binary alloys; hydrogen-purified; hydrogen-purified iron; iron; zone-refined iron.

Effects of impurities on yield and flow strength of hydrogen-purified, zone-refined iron and of dilute, binary alloys made from it in the temperature range 77-300 °K have been examined. Data from the literature are compared with new data obtained on hydrogen-purified iron and iron-0.01 and 0.026 wt. percent nitrogen alloys. In 300 °K tensile tests, hydrogen purification causes substantial changes in the shape of the upper yield, the magnitude of yield stress, the grain-size dependence of yield stress and the response to strain aging treatments. However, hydrogen purification decreases total interstitial impurity by only 0.0008 wt. percent.

Dilute iron alloys are found to exhibit unusual, but widely documented solution strengthening behavior. The room temperature strength is proportional to impurity concentration. However, low-temperature strength is inversely proportional to impurity concentration. This phenomenon, termed "alloy softening," is more pronounced in poly- than in monocrystals, and for interstitial than substitutional impurities.

It is concluded that hydrogen-purification of zone-refined iron affects mechanical behavior by modifying interstitial impurity distribution, rather than by total removal of interstitial impurity. Alloy softening may be due to an increase in mobile dislocation density related to solute rearrangements during thermal treatments.

10875. Chung, K., Danos, M., Huber, M. G., **Microscopic description of the absorption of bound π-mesons,** *Physics Letters* **29B,** No. 5, 265-267 (May 16, 1969).

Key words: Correlated pairs; high momentum components; meson nucleus interactions; nuclear wave function; π mesons; short range correlations.

The absorption rates of bound 1s and 2p pions in ^{16}O have been calculated on the basis of an extended shell model treatment. The effects of the short range part of the nucleon-nucleon interaction are introduced by a two-body correlation factor. It turns out that these correlations are essential; in particular the high momentum exchange between two nucleons seems to be the basic mechanism needed to account for the experimental π-absorption rate. It is possible to explain both 1s and 2p absorption rates in a consistent picture. Furthermore, the spectra of the emitted nucleons contain useful information about the details of the correlation factor.

10876. Clark, A. F., **Low temperature thermal expansion of some metallic alloys,** *Cryogenics* **8,** No. 5, 282-289 (Oct. 1968).

Key words: Alloys; aluminum; copper; expansivity; iron; metals; nickel; thermal expansion.

The low temperature thermal expansion of several aluminum, nickel, copper, and iron base alloys was measured from liquid hydrogen temperature, 20 K, to room temperature, 293 K. Both the thermal contraction from room temperature, $(L_{293} - L_T)/L_{293}$, and the thermal expansion coefficient, $1/L_{293}\ dL/dT$, are tabulated as a function of temperature. Comparison of similar alloys and alloy conditions led to the general conclusions that relatively large changes in composition are required to produce significant changes in the thermal expansion, thermal treatment or condition has little effect except when it produces a basic structure change, and the thermal expansion coefficient at room temperature is a good indicator of the total length change to a low temperature.

10877. Clark, A. F., Fickett, F. R., **A nonsuperconducting detection system for low level dc voltages,** *Rev. Sci. Instr.* **40,** No. 3, 465-468 (Mar. 1969).

Key words: DC voltage; low level; measurement.

A low level DC detection system with an attainable precision of 25 pV is described. The system utilizes only normal metal components and commercially available equipment. Measurements can be made automatically, in the presence of large (microvolt) spurious voltages, with switched inputs, and in a non "null" configuration. A typical application is described in detail.

10878. Clark, A. F., Powell, R. L., **Longitudinal magnetoresistance of pure single-crystal copper,** *Phys. Rev. Letters* **21,** No. 12, 802-804 (Sept. 16, 1968).

Key words: Copper; electronic scattering; magnetoresistance.

The longitudinal magnetoresistance was measured along the [100] direction of a pure single crystal of copper. The temperature dependence of the saturation ratio, ρ (B = sat.)/ρ (B = 0), is given between 4 and 35 K. A limit is placed on the diffusion approximation for small angle electron scattering and it is suggested that the assumption of a relaxation time or of a mean-free-path parallel to the velocity is not valid for some types of impurity or low temperature phonon scattering.

10879. Clark, H. E., Young, R. D., **Field emission through single strontium atoms adsorbed on a tungsten surface,** *Surface Sci.* **12,** 385-389 (1968).

Key words: Adsorption; energy distribution; field emission; Fowler-Nordheim curves; resonance tunneling; strontium; tungsten.

Measurements of the total-energy distribution and current-voltage characteristics (Fowler-Nordheim curves) are reported for electron emission through single strontium adatoms. A number of interpretations of these data are considered; resonance tunneling appears to be the most satisfactory.

10880. Cole, A. R. H., Lafferty, W. J., Thibault, R. J., **Rotational fine structure of the perpendicular band, ν_7, of ethane,** *J. Mol. Spectry.* **29,** No. 3, 365-374 (Mar. 1969).

Key words: C−H stretching region; Coriolis interaction; ethane; ground state rotational constants; perpendicular band; ν_7; upper state rotational constants.

The perpendicular band, ν_7, of ethane has been studied, and individual lines assigned in the sub-bands with $K\Delta K = +12$ to -5. An improved set of ground state constants has been obtained, and upper state constants are reported for the individual sub-bands.

10881. Coleman, J. A., Love, D. P., Trainor, J. H., Williams, D. J., **Effects of damage of 0.8 MeV-5.0 MeV protons in silicon surface-barrier detectors,** *NASA Rept.* No. x-611-68-221, 38 pages (National Aeronautics and Space Administration, Goddard Space Flight Center, Greenbelt, Md., June 1968).

Key words: Detector; proton; radiation effect; semiconductor; silicon.

Changes in the performance of silicon surface-barrier detectors after irradiation with protons at energies between 0.80 MeV and 5.00 MeV have been investigated for fluences up to 10^{17} protons cm^{-2}. Irradiations of the front, surface-barrier contacts and the rear, ohmic contacts of these transmission detectors were performed. In general, the detector current and noise increased with fluence. When the rear, ohmic contact was irradiated with protons which stopped within the detector, the changes in the current and noise after irradiation were several orders of magnitude smaller than after a similar irradiation of the front contact. For protons with energies greater than about 1 MeV, the detector capacitance decreased at low reverse biases and increased at high biases with increasing fluence. The results indicate that a significant reduction in the increase of detector current and noise can be obtained if the density or radiation-produced defects in the region of the junction is minimized.

10882. Cooper, M. J., Green, M. S., **Generalized scaling and the critical eigenvector in ideal Bose condensation,** *Phys. Rev.* **176,** No. 1, 302-309 (Dec. 5, 1968).

Key words: Bose condensation; critical eigenvector; critical phenomena; scaled equation of state.

We consider the condensation of a perfect Bose gas in which the phase symmetry of the Boson states has been removed by a linear coupling of the creation/annihilation operators $\psi^+(r)$, $\psi(r)$ to a fictitious external field $C(r)$ as a model of a second-order phase transition. In the vicinity of the transition, the spontaneous order parameter (thermal expectation value of ψ) is related to the conjugate field by a series of terms of which the first represents a scaled equation of state that exhibits a power-law behavior with non-classical exponents. The expectation value for the ordered product of Boson operators $\langle\psi^+(1)\psi^+(2)\ldots\psi^+(M)\psi(1)\ldots\psi(N')\rangle$ is determined and its behavior across the coexistence curve discussed. The existence of a conjectured critical eigenvector is demonstrated and a related asymptotic property of the ordered product determined.

10883. Cooper, M. J., **Point transformation of classical hard-core potential,** *J. Math. Phys.* **9,** No. 4, 571-578 (Apr. 1968).

Key words: Canonical point-transformation; dependent interactions; equivalent non-singular potential; hard-sphere gas; kinetic equation; many-body analysis; non-local velocity.

The method of an extended canonical point-transformation is used to reformulate the singular repulsions in a classical hard-sphere gas as equivalent velocity dependent interactions. The approach provides a Hamiltonian in which the repulsions appear as non-local potential interactions between the particles and may therefore be treated within any of the conventional perturbation methods of many-body analysis. Application of the technique to obtain a kinetic equation for a hard-sphere gas is obtained.

10884. Coriell, S. R., Jackson, J. L., **Bounds on transport coefficients of two-phase materials,** *J. Appl. Phys.* **39,** No. 10, 4733-4736 (Sept. 1968).

Key words: Composite materials; effective conductivity; transport coefficients; two phase materials; upper and lower bounds.

Previously derived upper and lower bound expressions for the effective conductivity of composite materials are applied to two phase materials. Results are presented for several simple geometrical arrangements and for certain limiting cases.

10885. Corruccini, R. J., **Principles of thermometry (measurement of temperature),** Chapter 87 in *Treatise on Analytical Chemistry, Part I, Theory and Practice,* I. M. Kolthoff, P. J. Ebring, and E. B. Sandell, eds., **8,** 4937-4990 (Interscience Publ., Inc., New York, N.Y., 1968).

Key words: Temperature; temperature measurement; thermometry.

From fundamental thermodynamic concepts the idea of temperature as a quantitative parameter is developed. It is shown how scales of temperature are defined, and how they are accurately realized in practice and transmitted to lower orders of practical thermometers. The operating principles and characteristics of expansion thermometers, resistance thermometers, thermocouples, and radiometric thermometers are presented in some detail.

10886. Coxon, B., **P.M.R. evidence for the conformations of 1,2-O-benzylidene-α-D-glucofuranose derivatives,** *Carbohydrate Res.* **8,** 125-134 (1968).

Key words: Benzylidene acetals; chemical shifts; conformations; D-glucofuranose derivatives; p.m.r. spectroscopy; proton coupling constants.

Proton coupling constants and chemical shifts of two 1,2-*O*-benzylidene- and four 1,2:3,5-di-*O*-benzylidene-α-D-glucofuranose derivatives have been measured by p.m.r. spectroscopy at 100 MHz. From these parameters, it is deduced that the furanoid rings of the mono- and di-benzylidene acetals exist mainly in symmetric and non-symmetric twist conformations, respectively. The *m*-dioxane ring of the dibenzylidene acetals adopts that chair conformation in which C-6 is axially attached.

10887. Creitz, E. C., **Construction details and measurements of response of a gas density balance,** *J. Chromatog. Sci.* **7,** 137-144 (Mar. 1969).

Key words: Chromatographic detector; density detector; gas density; gas detector.

The measured response of the Nerheim gas density balance using hot wire anemometers as sensing elements, was compared with the predicted response for such variables as anemometer match, resistance to flow in the exit branches of the duct system, changes in bridge current and reference gas flow rate. Criteria are given for selecting matched pairs of anemometers and for their calibration in the gas flow system. Proper selection of an operating point, in terms of reference gas velocity, permitted detection of differences in flow rates as small as 1.4×10^{-3} cm s^{-1}. The measured overall sensitivity for oxygen and for methane, using nitrogen as the reference gas, was 0.534×10^6 and 0.616×10^6 millivolts per density unit (g cm^{-3}), respectively.

10888. Crumlish, J. D., **Notes on U.S. Government information systems,** *Law Computer Technol.* **1,** No. 11, 15-21 (Nov. 1968).

Key words: Computer technology; documentation, federal systems; Government research and development information; information systems; scientific communication.

U.S. Government agencies have developed a number of information systems to help fulfill their statutory missions. Of the two primary types of non-military systems, one is outlined in this article: research and development information systems; telling who is doing what, where, and in some cases, how. The second major classification, statistical information systems; for the development, collection, analysis, and dissemination of data, are reserved for later treatment.

A sampling is described here to aid those interested in developing new systems or in making better use of, and coordinating with, those outlined herein.

10889. Cuthill, J. R., Dobbyn, R. C., McAlister, A. J., Williams, M. L., **Search for plasmaron structure in the soft x-ray L$_{2,3}$ emission spectrum of Al,** *Phys. Rev.* **174,** No. 2, 515-517 (Oct. 10, 1968).

Key words: Aluminum; electron gas; emission spectrum; excitations; plasmaron; soft x-ray.

The L$_{2,3}$ soft x-ray emission spectrum of Al has been carefully scanned for a weak low energy edge predicted by recent theoretical studies of the interacting electron gas. A very weak structure, near the predicted location, but just within the noise, is seen. An upper limit to the magnitude of such structures is established, and it is suggested that the light alkali metals should provide a better test of the theory.

10890. Cuthill, J R., McAlister, A. J., Williams, M. L., Dobbyn, R. C., **Soft x-ray spectra and comparison with the theoretical density of states,** (Proc. Conf. Soft X-ray Band Spectra and the Electronic Structure of Metals and Materials, Strathclyde, Scotland, Sept. 18-21, 1967), Chapter in *Soft X-ray Band Spectra and the Electronic Structure of Metals and Materials. Part II. Heavy Metal and Alloy Spectra and Comparison with other Optical Methods,* pp. 151-162 (Academic Press Inc., New York, N.Y., 1968).

Key words: Aluminum; density of states; L-emission band, M-emission band; Ni-Al system; nickel; soft x-ray spectroscopy; TiNi intermetallic compound; transition probability energy.

Emission spectra are being obtained with a 2-meter grazing incidence glass grating (30,000 lines/inch) spectrometer with photoelectron detection and digital recording. The long range objective is information pertaining to the changes in the density of states with alloying and intermetallic compound formation. However, most of the effort to date has been on the determination of the nickel-M$_{2,3}$ spectrum and its relation to the density of states in nickel. The temperature was held at 960 ± 7 °C to insure an oxide-free surface. A number of scans were summed to resolve detail that has not been resolved heretofore. Calculated transition probabilities appear to account for the observed L band always being narrower than the M.

A comparison of Al-L$_{2,3}$ and Ni-M$_{2,3}$ overlapping spectra from NiAl$_3$, NiAl, and 8 and 4 percent Al in nickel solid solutions together with the spectra of the pure metals, reveals certain major features of the soft x-ray spectra to be unrelated to crystal structure. The observed spectra suggest that the electronic structure of the aluminum undergoes a progressive change with increasing nickel content whereas the high energy x-ray L emission edge remains unshifted at least up to 50 percent Ni. In contrast to the Ni-Al system there is no overlap of the titanium-M$_{2,3}$ spectrum with the nickel-M$_{2,3}$ spectrum in the case of the Ti-Ni system. The nickel-M$_{2,3}$ from Ni in TiNi exhibits a peak at the same energy as that of the peak in the pure Ni spectrum but also exhibits a much larger peak about 3 eV lower in energy.

10891. Cutkosky, R. D., **A varactor null detector for audio frequency capacitance bridges,** *IEEE Trans. Instr. Meas.* **IM-17,** No. 4, 232-238 (Dec. 1968).

Key words: Audio amplifier; capacitance bridge detector; noise reduction; null detector; parametric amplifier; varactor amplifier.

A two-varactor, double sideband up-converter pumped at 30 MHz has been constructed. Operated at room temperature with a signal frequency of 10^4 radians per second, the device has an optimum source resistance of 10^5 ohms and a minimum noise figure of 0.01 dB. Immersed in liquid N_2, minimum noise figures below 0.001 dB referred to a room temperature source have been measured. The device is particularly useful as a null detector for audio frequency capacitance bridges. At 10^4 radians per second, a signal current of 10^{-14} A through a capacitance of 1000 pF can be detected in less than one second with this instrument. Techniques for suppressing microphonics and other extraneous sources of noise are described.

10892. Czyz, W., Maximon, L. C., **High energy scattering of strongly interacting composite particles,** *Physics Letters* **27B**, No. 6, 354-357 (Aug. 19, 1968).

Key words: Hadron-hadron scattering; high-energy cross sections; high energy scattering; nucleon-nucleus scattering.

High energy electron-nucleus, nucleon-nucleus and nucleus-nucleus scattering are analyzed in the framework of geometrical optics. It is shown that good agreement with experimental cross sections is obtained provided that a correction for the center of mass motion is included.

10893. Czyz, W., Maximon, L. C., **High energy small angle elastic scattering of strongly interacting composite particles,** *Ann. Phys.* **52,** No. 1, 59-121 (Mar. 1969).

Key words: Deuteron-deuteron scattering; elastic scattering; hadrons; high energy scattering; proton-nucleus scattering; strongly interacting particles.

Starting from a simple-minded formulation of the Glauber model of the high energy multiple scattering of strongly interacting composite particles, several generalizations and limiting expressions are derived from the elastic scattering amplitudes at small scattering angles. An extensive discussion of the many possible applications to nucleon-nucleus, nucleus-nucleus and other composite hadron elastic scattering processes is given.

10894. Danielson, B. L., **An optical Faraday rotation technique for the determination of magnetic relaxation times,** *IEEE Trans. Mag.* **MAG-4,** No. 2, 176-178 (June 1968).

Key words: Faraday effect; paramagnetic relaxation.

A technique is described for the measurement of spin-spin and spin-lattice relaxation times in crystals using the optical Faraday rotation as a monitor of the magnetization. The method is applied to the paramagnetic Eu^{2+} ion in CaF_2:Eu^{2+}. In this experiment the crystal is placed between a crossed polarizer and analyzer and subjected to a pulsed magnetic field. The transmitted light from a cw argon-ion laser gives a direct indication of the spin relaxation time. Some possible advantages of this technique for the determination of fast relaxation times in concentrated systems are discussed.

10895. Davis, D. D., Braun, W., **Intense vacuum ultraviolet atomic line sources,** *Appl. Opt.* **7,** No. 10, 2071-2074 (Oct. 1968).

Key words: Atomic lines; Br; C; flow lamp; N; O; photochemistry; vacuum ultraviolet.

Intense atomic lines (O, N, S, C, Br, Cl, H, Xe, Kr) have been produced by microwave excitation of mixtures of various gases in helium under flow conditions. The intensities generally obtained are greater than 10^{14} quanta/sec and are suitable for atomic fluorescence studies and as photochemical light sources in the vacuum ultraviolet. Conditions for producing these high purity line sources are discussed.

10896. Davis, D. D., Okabe, H., **Determination of bond dissociation energies in hydrogen cyanide. Cyanogen and cyanogen halides by the photodissociation method,** *J. Chem. Phys.* **49,** No. 12, 5526-5531 (Dec. 15, 1968).

Key words: Bond dissociation energies; BrCN; ClCN; CN; C_2N_2; FCN; fluorescence; HCN; ICN; photodissociation; vacuum ultraviolet.

The photodissociation process yielding CN $B^2\Sigma^+$ from various cyanogen compounds has been studied in the vacuum ultraviolet. Threshold energies of incident photon to produce the CN $B^2\Sigma^+$ are measured by monitoring the fluorescence due to the transition CN $B^2\Sigma^+ - X^2\Sigma^+$. The upper bounds of bond energies can be obtained from these thresholds and the electronic energy of CN $B^2\Sigma^+$. The average heat of formation of CN and its estimated overall uncertainty. $\Delta Hf_0^\circ(CN) = 418 \pm 4$ kJ mol^{-1} (100 ± 1 kcal mol^{-1}), is computed using these bond energies together with various ΔHf_0°. This value is within an estimated error in excellent agreement with the photoionization value recently obtained by Dibeler and Liston. The bond energies based on $\Delta Hf_0^\circ(CN) =$ 418 kJ mol^{-1} (100 kcal mol^{-1}) for various cyanogen compounds are $D(H-CN) = 497$ (119), $D(Cl-CN) = 401$ (96), $D(Br-CN) = 343$ (82), $D(I-CN) = 301$ (72), $D(NC-CN) = 531$ (127), $D(C-N) = 765$ (183) all in kJ mol^{-1} (kcal mol^{-1}) with an overall estimated error of $\pm$ 4 kJ mol^{-1} (1 kcal mol^{-1}). Because of the weak fluorescence intensity, no reliable bond energy was obtained for CH_3CN. Other values obtained are $D(F-CN) \leqslant 464$ kJ mol^{-1} (111 kcal mol^{-1}) and $\Delta Hf_0^\circ(FCN) \geqslant 30.9$ kJ mol^{-1} (7.4 kcal mol^{-1}). A correlation of the dissociation process with the absorption spectrum is briefly discussed. A comparison is made of bond energies obtained by the photodissociation, photoionization, and electron impact methods. Limitations of the photodissociation method to determine bond energies are discussed.

10897. Davis, G. T., Eby, R. K., Martin, G. M., **Variations of the unit cell dimensions of polyethylene: effect of crystallization conditions, annealing, and deformation,** *J. Appl. Phys.* **39,** No. 11, 4973-4981 (Oct. 1968).

Key words: Annealing; crystallization; deformation; density; fold surface; melt; polyethylene; solvent; temperature; time; unit cell.

It is shown that the orthorhombic unit cell dimensions of a given polyethylene are not unique but depend upon physical and thermal history. For polymer crystallized from a 3/4 percent p-xylene solution, the values of *a* and *b* determined by the powder camera technique vary (up to 0.6 percent) systematically with crystallization temperature (50 °C, 70 °C, 90 °C) and the temperature of annealing (up to 127 °C). For "undeformed" crystals, the changes with annealing appear to accompany the increase in crystal thickness and for deformed crystals, they occur over a wider range of temperatures—even below the crystallization temperature. The dimensions change within the first two minutes of annealing and appear to be independent of time thereafter. The only exception observed is a slow decrease of *b* with time upon annealing at 100 °C. Crystals grown from other solvents exhibit very nearly identical effects and the presence of solvents does not alter the cell dimensions at room temperature. Similar effects are observed for crystals grown from the melt by slow cooling, quenching in ice water, and quenching in a dry ice-acetone suspension. The main difference is that cold working does not appear to alter the effects of annealing. The mechanism of the effects cannot be safely assigned but changes in the fold surface probably play a role and a discussion relevant to this and other mechanisms is presented. Corresponding to the changes in cell dimension are changes in cell density which are, however, too small to account for the frequently reported discrepancy between crystal and unit cell density. The effects of cell variation must be considered in interpreting the variation of physical properties.

10898. Delaplane, R. G., Ibers, J. A., Ferraro, J. R., Rush, J. J., **Diffraction and spectroscopic studies of the cobaltic acid system $HCoO_2$-$DCoO_2$,** *J. Chem. Phys.* **50,** No. 5, 1920-1927 (Mar. 1, 1969).

Key words: Cobaltic acid; crystal structure; hydrogen bond; infrared spectra; isotope effect; lattice vibrations; neutron spectra; selection rules.

Cobaltic acid, $HCoO_2$, and deuterated cobaltic acid, $DCoO_2$, have been prepared and studied by x-ray and neutron diffraction techniques, and by infrared spectroscopy and cold-neutron scattering. The materials crystallize in apparent space group D_{3d}^5-R3m of the trigonal system with three molecules in a hexagonal cell of dimensions: $HCoO_2$, a = 2.851 ± 001, c = 13.150 ± 005 Å; $DCoO_2$, a = 2.854 ± 001, c = 13.354 ± 005 Å. The O-O distance, as determined by neutron powder studies, of $HCoO_2$ is 2.50 ± 02 Å. On this basis and the fact that there are three O-H-O bonds along the *c* direction, the O-D-O distance is 2.57 ± 02 Å. Hence, the isotope effect here is as large as in the system $HCrO_2-DCrO_2$. Infrared studies at room temperature and at −195 C over the region 70 to 4000 cm^{-1} may be interpreted in terms of an effectively symmetric O-H-O bond and an effectively asymmetric O-D-O bond. Although the neutron inelastic scattering measurements are not inconsistent with this interpretation, there is an intense band centered at 264 cm^{-1} in the neutron spectrum for $HCoO_2$ that remains unexplained. Model calculations, based on a two-dimensional potential function in which the asymmetric stretching frequency is coupled to the symmetric stretching frequency, were unsuccessful owing to the magnitude of the coupling term required to account for the very large isotope effect.

10899. Deslattes, R. D., **Estimates of x-ray attenuation coefficients for the elements and their compounds,** *Acta Cryst.* **A25,** Part 1, 89-93 (Jan. 1969).

Key words: Absorption fine structure; mixture rule; x-ray attenuation.

Some recent developments leading to improved knowledge of the distribution of oscillator strength in the photoionization continua of atoms are briefly reviewed. Selective comparisons between the experiments and calculations are indicated. Estimates for attenuation by compounds and solids, insofar as they depart from the mixture rule, require an understanding of x-ray fine structure or, at least of its limiting form, which is not yet at hand. Some of the mechanism leading to fine structure in solids and molecules are briefly reviewed.

10900. Dibeler, V. H., Walker, J. A., **Mass spectrometric study of photoionization. XIII. Boron trichloride and diboron tetrachloride,** *Inorg. Chem.* **8,** No. 1, 50-55 (Jan. 1969).

Key words: BCl_3; bond dissociation energies; B_2Cl_4; heats of formation; ions; mass spectrometry; radicals; vacuum ultraviolet.

Mass spectra and ion-yield curves for the molecule ions and various fragment ions of BCl_3 and B_2Cl_4 are obtained by means of a combined vacuum ultraviolet monochromator and mass spectrometer. Shapes of ion-yield curves measured over the wavelength region from threshold to 600 Å, are discussed briefly. Ionization threshold values are used to calculate heats of formation of ions and radicals and to derive bond dissociation energies, including the boron-boron bond dissociation energy, $D_0(Cl_2B-BCl_2) = 3.80$ eV (87.6 kcal mol^{-1}).

10901. Dibeler, V. H., Liston, S. K., **Mass spectrometric study of photoionization. XII. Boron trifluoride and diboron tetrafluoride,** *Inorg. Chem.* **7,** No. 9, 1742-1746 (Sept. 1968).

Key words: BF_3; bond energies; B_2F_4; heats of formation; ionization; mass spectra; photoionization; vacuum ultraviolet.

Mass spectra and photon yield curves for the molecular and principal fragment ions of BF_3 and B_2F_4 are reported. The threshold regions only are measured for $B_2F_3^+$ and BF^+ from B_2F_4. These observations are intercompared in order to derive heats of formation of ions and radicals and bond dissociation energies. The boron-boron bond dissociation energy in B_2F_4 is calculated to be 431 kJ mol^{-1} (103 kcal mol^{-1}).

10902. Dibeler, V. H., Liston, S. K., **Mass spectrometric study of photoionization. IX. Hydrogen cyanide and acetonitrile,** *J. Chem. Phys.* **48,** No. 10, 4765-4768 (May 15, 1968).

Key words: CH_3CN; dissociation; HCN; heats of formation; ionization; mass spectrometry; threshold energies; vacuum ultraviolet.

Photoionization yield curves are obtained from threshold to 600 Å for the HCN^+ and CN^+ ions of HCN and for the principal ions of CH_3CN. The first ionization energy of HCN is 13.59 eV. The threshold for CN^+ ion permits calculation of $\Delta Hf_0^\circ(CN) =$ 100 kcal mol^{-1}, $D_0(CN) = 182.5$ kcal mol^{-1}, $D_0(H-CN) = 119.2$ kcal mol^{-1}, and $D_0(NC-CN) = 126.6$ kcal mol^{-1}. Dissociative photoionization processes in acetonitrile do not produce methyl or cyanogen radical ions in sufficient abundance for direct verification of the above. Nevertheless, threshold values of the principal photoions of CH_3CN are tabulated, and some thermodynamic values are calculated, including $\Delta Hf_0^\circ(CH_2) = 94$ kcal mol^{-1}.

10903. Dibeler, V. H., Liston, S. K., **Mass spectrometric study of photoionization. XI. Hydrogen sulfide and sulfur dioxide,** *J. Chem. Phys.* **49,** No. 2, 482-485 (July 15, 1968).

Key words: Dissociation; heats of formation; H_2S; ionization; mass spectrometer; photoionization; SO_2; vacuum ultraviolet.

Photoionization yield curves are obtained for the molecule and fragment ions of H_2S and SO_2 from onsets of ionization to 600 Å. Structural features of the curves are discussed. Ionization thresholds are tabulated and heats of formation of ions and radicals are calculated. Derived quantities (in kcal mol^{-1}) include: $D_0(HS-H) = 89.3$, $D_0(SH) = 83.2$, $\Delta Hf_0^\circ(S) = 65.0$, $D_0(S_2) =$ 99.4, and $D_0(OS-O) = 129.1$. The ionization energy, I(SO) = 10.21 eV is obtained by indirect means.

10904. Dick, C. E., Motz, J. W., **Inelastic scattering cross sections for 200- and 400-keV electrons,** *Phys. Rev.* **171,** No. 1, 75-80 (July 5, 1968).

Key words: Aluminum; atomic binding effects; copper; gold; inelastic cross sections; ionization processes; large angle electron scattering; tin; 200 keV; 400 keV.

With 200 and 400 keV electrons incident on thin targets of aluminum, copper, tin, and gold, experimental data are given for the pulse height distributions produced in a silicon detector by the electrons scattered at angles of 40, 90, 120 and 140 degrees. These distributions were analyzed to determine the inelastic cross sections integrated over the energies of the scattered electrons in the energy region below the elastic peak. This lower energy region involves energy transfers that are large compared to the atomic binding energies and most probably involves atomic ionization processes. The results show that these inelastic scattering cross sections increase sharply for angles larger than 90 degrees, so that the ratio of the inelastic to the elastic cross sections becomes larger than unity. In addition, these large angle inelastic cross sections increase with the atomic number of the target and with the average binding energy per target electron. Because of the unavailability of accurate calculations for this process, comparisons are made with the Møller cross sections for electron-electron scattering in order to demonstrate how atomic binding influences large angle inelastic scattering.

10905. Dickson, R. W., Spinner, S., **An improved method for the determination of torsional and flexural resonance frequencies of cylindrical specimens,** *J. Mater.* 3, No. 3, 716-724 (1968).

Key words: Cylinders; loop; suspension; torsional mechanical resonance frequency.

A suspension method is described for obtaining torsional as well as flexural mechanical resonance frequencies of cylindrical specimens which overcomes many of the difficulties previously encountered in determining the torsional modes for such specimens. The method is readily adaptable for such measurements as a function of temperature. Also internal friction measurements using this method yield responses having less suspension losses than other suspension systems, resulting in more reliable values of internal friction from the specimen.

10906. Diller, D. E., **Refractive index of gaseous and liquid hydrogen,** *J. Chem. Phys.* **49,** No. 7, 3096-3105 (Oct. 1, 1968).

Key words: Clausius-Mossotti function; Lorentz-Lorenz function; molecular polarizability; orthopara composition; parahydrogen; refractive index.

The refractive index of gaseous and liquid hydrogen has been measured by an interferometric method at temperatures between 15 and 298.15 °K and at pressures up to 230 atm. The measurements have been analyzed in terms of the density and temperature dependence of the Lorentz-Lorenz function,

$$L-L \equiv (n^2_\lambda - 1)/(n^2_\lambda + 2) \cdot 1/\rho,$$

where n_λ is the refractive index at $\lambda = 5462$ Å and ρ is the fluid density in g/cm^3. The precision and reproducibility of L − L is better than 0.05 percent in most cases.

L − L for gaseous parahydrogen first increases with increasing density to a maximum and then decreases to a value below the low density limit. L − L is also slightly temperature dependent; the low density limit increases with increasing temperature; the maximum on the L − L isotherms decreases with increasing temperature. L − L for saturated liquid parahydrogen decreases with increasing density by about 0.1 percent at temperatures between 15 and 32 °K. The difference in L − L for normal and parahydrogen is consistent with previous theoretical and experimental estimates of the molecular polarizability difference.

10907. Dise, J. R., **Significance of the test for normal consistency of hydraulic cement,** *Am. Soc. Testing Mater. Spec. Tech. Publ.* **441,** *Cement, Comparison of Standards and Significance of Particular Tests,* pp. 3-15 (Aug. 1968).

Key words: Autoclave soundness; hydraulic cement; normal consistency; tensile strength; time of setting; Vicat.

The Vicat Test for Normal Consistency was devised in France approximately 150 years ago and has been in use as a standard ASTM method of test for hydraulic cements since 1904. Much has been learned about the relationship between normal consistency and various other properties of these materials from the numerous studies of related questions that have been carried out over the years. A summation of the information that has been developed concerning time of setting, autoclave soundness and tensile strength tests, and other subjects of potential interest to those engaged in the development of specifications and methods of test for cements, is presented in this review.

10908. Douglas, T. B., King, E. G., **High-temperature drop calorimetry,** Chapter 8 in *Experimental Thermodynamics,* **Vol. I,** *Calorimetry of Non-reacting Systems,* J. P. McCullough and D. W. Scott, eds., pp. 293-331 (Butterworth and Co., London, England, 1968).

Key words: Calorimetric methods; calorimetry; drop calorimetry; thermodynamic properties.

The principles and techniques of the drop method of determining relative enthalpies of solids and liquids above room temperature are discussed in detail and critically, with particular attention to those features which lead to the most accurate results. Typical precise results are compared with those obtained using other calorimetric methods, and the advantages and disadvantages of the drop method are considered. While alternative accessories are referenced and discussed briefly, two important types of furnace (with and without a good thermal conductor) and two types of calorimeter (the "ice" and "copper-block") are treated in detail with respect to their design, construction, and operation with accuracy and convenience. Numerous sample and container problems peculiar to high temperatures are considered. Finally, various aspects of treating the data are dealt with. These aspects include correcting to standard conditions, correcting for chemical impurities and irrelevant phase changes, smoothing and representing enthalpy values, derivation of other thermodynamic properties from enthalpies, and the evaluation and representation of simple expressions of precision and accuracy.

10909. Dragoo, A. L., **Diffusion rates in solids,** Chapter IV in *Atomic Energy Review,* O. Kubaschewski, ed., **2,** 187-202 (International Atomic Energy Agency, Vienna, Austria, 1968).

Key words: Borides; carbides; diffusion rates; nitrides; oxides of nuclear materials.

A discussion of the types of diffusion coefficients and of the experimental techniques for their determination is presented for inclusion in the International Atomic Energy Agency Monograph Series on the Physicochemical Properties of Nuclear Materials. The diffusion coefficients for tracer diffusion, self-diffusion, intrinsic diffusion, chemical inter-diffusion and grain-boundary diffusion are described. Experimental methods and limitations are discussed for (1) metallic and metalloid ion diffusion in borides, carbides, nitrides and oxides of Be, Ti, Zr, Hf, Nb, Ta, Mo, Th and U; (2) diffusion of B, C, N and O in metals; and (3) rare gas diffusion from compounds used as nuclear fuels.

10910. Drechsel, D., **On the model-independent evaluation of inelastic electron scattering data at low momentum transfer,** *Nucl. Phys.* **A113,** No. 3, 665-675 (June 7, 1968).

Key words: Correction factors; Coulomb effects; electro-excitation; low momentum transfer; magnetic transitions; model-independent evaluation; phase shift analysis; transition radius.

At low momentum transfer, electro-excitation experiments may be corrected for the static Coulomb effects in a model-independent way. This is demonstrated in the case of magnetic transitions for various phenomenological current and magnetization distributions. The inclusion of a finite excitation energy gives mainly a kinematical effect. It is further shown that for transverse transitions the notion of a "transition radius" has no model-independent physical meaning and should be avoided.

10911. Drechsel, D., Maximon, L. C., **Potential model calculation for coplanar and noncoplanar proton-proton bremsstrahlung,** *Ann. Phys.* **49,** No. 3, 403-444 (Oct. 1968).

Key words: Angular distributions; low energy approximation; non-coplanarity; off-the-energy-shell matrix elements; photon; potential model calculations; proton-proton bremsstrahlung.

The cross section for proton-proton bremsstrahlung is calculated for both coplanar and non-coplanar events using the Hamada-Johnston and Reid (soft-core) potentials. Agreement is obtained with the experimental data for angular distributions and cross sections integrated over the photon directions. We present a detailed analysis of the kinematics, the phase space and the matrix element in the neighborhood of the kinematic limit of non-coplanarity. We find a rapid decrease of the cross section integrated over photon angles as this limit is approached. This is due, not to a strong variation of the phase space, which is essentially constant, but to the fact that near the kinematic limit for non-coplanarity of the protons, the photon is restricted to angles for which the probability for emission is small. For low energies (< 30 MeV) of the incident proton we give analytic expressions for the scattering amplitude, valid for coplanar as well as the non-coplanar events.

10912. Driver, L. D., Arthur, M. G., **A wideband RF voltmeter-comparator,** *IEEE Trans. Instr. Meas.* **IM-17,** No. 2, 146-150 (June 1968).

Key words: Detector networks; differential voltmeter; voltage comparator; voltage monitor; voltmeter.

This paper describes a new, wide-band RF voltmeter/comparator for the frequency range dc to 1 GHz and the voltage range 1 to 15 volts. The device employs matched hot-carrier diodes in a dual channel 50 ohm coaxial configuration. Power extraction from the signal under test is negligible and the coaxial line sections are impedance compensated so that the maximum VSWR is 1.02. Applications include the following: (1) Measurement of RF voltage with 3 percent uncertainty limit. (2) Measurement of differential RF voltage. (3) High resolution RF voltage comparator-monitor. (4) Leveler-detector, with flat response, for swept or fixed frequency operation.

10913. Duerst, R. W., Baum, S. J., Kokoszka, G. F., **Exchange coupling in two dimeric copper adenine complexes,** *Nature* **222,** 665-666 (May 17, 1969).

Key words: Adenine; copper(II); EPR spectra; exchange coupling; metal ion pairs; optical spectra; purine bases.

The electron paramagnetic resonance spectra of two copper(II)-adenine complexes, $Cu_2(C_5H_5N_5)_4(ClO)_4 \cdot nH_2O$(I) and $Cu_2(C_5H_4N_5)_4 \cdot 4H_2O$ (II), are characteristic of a species with a spin of one, a condition which may arise if two copper(II) ions, each with a spin of one-half, are exchange coupled. Further evidence for the dimeric complex is furnished by the seven line hyperfine pattern in the parallel and zero field regions of the spectrum, observed for both complexes. The magnetic parameters are $g_{\|}=2.22\pm.03$, $g_{\perp}=2.05\pm.01$, $D=(0.110\pm.005)$ cm^{-1}, $E<0.03$ cm^{-1}, $(A_{\|})/2=(88\pm3)\cdot10^{-4}$ cm^{-1}, and $A_{\perp}<0.002$ cm^{-1} for I, and $g_{\|}=2.19\pm.03$, $g_{\perp}=2.05\pm.01$, $D=(0.121\pm.005)$ cm^{-1}, $E<0.03$ cm^{-1}, $(A_{\|})2=(81\pm8)\cdot10^{-4}$ cm^{-1}, and $A_{\perp}<0.002$ cm^{-1} for II. The indicated error limits are estimated uncertainties. A temperature variation study of the line intensity over the range 77 to 300 K indicates that the triplet state lies 300±60 cm^{-1} and 160±60 cm^{-1} above the singlet ground state for I and II respectively.

10914. Dunn, G. H., **Colliding beams,** (Proc. First Intern. Conf. Atomic Physics, New York, N.Y., June 3-7, 1968), Chapter in *Atomic Physics,* B. Bederson, V. W. Cohen, F. M. J. Pichanick, eds., pp. 417-433 (Plenum Press Inc., New York, N.Y., 1969).

Key words: Atomic physics; colliding beams; review; technique.

Variations of the colliding beams technique are compared with one another from the standpoint of energy range accessible, energy spread in the beams, and systematic errors in the experiments. Advantages and disadvantages of different variations are pointed out.

10915. Edelman, S., Roth, S., Grisham, L., **Electrical generation of motion in elastomers,** *Shock and Vibration Bull.* **39,** Part 2, 18 pages (Shock and Vibration Information Center, Naval Research Laboratory, Washington, D.C., Feb. 1969).

Key words: Elastomers; electrets; electrically controlled damping; electrostriction; piezoelectricity; polymers; vibration generation.

Motion occurring in response to an applied electrical signal was studied in a number of elastomers. Motion at double the exciting frequency (electrostriction) was common. Linear response was found in a few materials. A few showed linear response in their original condition. Treatment with heat and intense electric fields caused linear response to appear or to increase in others. Superposition of a d.c. bias on the driving signal linearized the double frequency response and increased the linear response.

10916. Edmiston, C., Krauss, M., **Pseudonatural orbitals as a basis for the superposition of configurations. II. Energy surface for linear H_3,** *J. Chem. Phys.* **49,** No. 1, 192-205 (July 1, 1968).

Key words: Correlation energy; electronic energy surface; Gaussian-type functions; Hartree-Fock; H_3; superposition of configurations.

A superposition of configurations (SOC) trial function is applied to the H_3 energy surface. The convergence of the SOC trial function is improved by constructing the configurations with approximate or pseudo-natural orbitals (PNO). For a given atomic function basis the PNO exhaust the accuracy of that basis in relatively few configurations compared to the total of all possible configurations. Gaussian-type functions (GTF) are then practicable as a basis for a SOC trial function.

Results are presented for the linear H_3 energy surface. The error when one hydrogen is removed to infinity is 0.1 eV and an extrapolation of this error yields a "probable" activation energy of 0.53 eV or 12 kcal.

10917. Edmonds, J., **Matroid partition,** Chapter in *Mathematics of the Decision Sciences, American Mathematical Society Lectures in Applied Mathematics* **11,** 335-345 (American Mathematical Society, Providence, R.I., 1968).

Key words: Algorithm; combinatorics; forests; matroid; partition; transversals.

For an indexed family of matroids, $M_i=(E,F_i)$, all defined on the same set E, an algorithm is described for partitioning any $H \subseteq E$, if possible, into sets I_i such that $I_i \in F_i$. Some applications are described. It is shown that the subsets H which can be partitioned in this way comprise the independent sets of a matroid which we denote as $M=\Sigma M_i$, the sum of matroids M_i. So-called *transversal matroids* are described as sums of rank-one matroids.

10918. Ehrlich, M., **Influence of irradiation rate on the production of F centers in LiF (TLD grade),** (Proc. Second Intern. Conf. Luminescence Dosimetry, Gatlinburg, Tenn., Sept. 23-26, 1968), J. A. Auxier, K. Becker, E. M. Robinson, eds., Paper No. CONF-680920 Health and Safety (TID-4500), pp. 322-326 (Oak Ridge National Laboratory, Oak Ridge, Tennessee, Sept. 1968); *J. Appl. Phys.* **40,** No. 2, 891-892 (Feb. 1969).

Key words: F-center formation; LiF(TLD grade); rate dependence; thermoluminescence; ^{60}Co gamma radiation.

Optically polished samples of extruded plaques of LiF(TLD grade) were given ^{60}Co gamma-ray exposures ranging from about 30 000 R(9 C/kg) to 450 000 R(120 C/kg), at exposure rates between about 1.5×10^3 R/h (0.39 C/kg h) and 5×10^6 R/h 1300 C/kg h). Over this range of exposures and exposure rates, the resulting absorption in the F band was found to be independent of exposure rate, and to increase with exposure, even for exposures for which the thermoluminesence exhibited saturation effects. After thermoluminescence readout at about 235 °C, practically all the absorption in the F band created by the ^{60}Co gamma-ray exposures had disappeared. These results are compatible with the dominant role given F centers in some of the current models for the thermoluminescence process in LiF(TLD grade).

10919. Unassigned.

10920. Ehrlich, M., **Personal dosimetry: methods other than T.L.D.,** *Proc. First Intern. Congress Radiation Protection, Rome, Italy, Sept. 5-10, 1966,* Part 1, pp. 69-76 (Pergamon Press Inc., New York, N.Y., 1968).

> Key words: Calibration; data processing; evaluation; gamma rays; intercomparison; performance; personnel dosimetry; phosphate glass; photographic film; radioactive sources; thermal neutrons; x rays.

This is the rapporteur paper that was presented by the author on September 5, 1966, at the first International Congress of the International Radiation Protection Association, in Rome, Italy. The following eight papers were covered: Photographic dosimetry: beta-gamma calibration, M. P. Olivares, S. Perez-Modrego (Spain); Transportable calibration facility for film dosimetry of x-rays by means of radioactive sources, V. Paič (Yugoslavia); A new concept in film badge design, J. D. Eastes, M. L. Maurer, F. L. Paschal (U.S.A.); A phosphate glass dosimeter adapted to the requirements of health physics applications, W. Buttler, R. Maushart, E. Piesch (Federal Republic of Germany); Personnel film monitoring in Poland: organization, method, results, T. Musiałowicz (Poland); Practical personnel dosimetry of thermal neutrons, D. Nachtigall (Switzerland), E. Rose (Federal Republic of Germany); Automatic data processing of a film badge service, W. Benari, M. Schatz, G. Ben-David (Israel); Expérience pratique de dosimétrie comparée dans les six pays d'Euratom (premiers résultats), M. Collet, P. Recht (Euratom).

10921. Ehrlich, M., **Thermoluminescence response of LiF to x and gamma rays; a study of rate energy dependence over a wide range of exposures,** *Proc. First. Intern. Congress Radiation Protection, Rome, Italy, Sept. 5-10, 1966,* pp. 429-434 (Pergamon Press Inc., New York, N.Y., 1968).

> Key words: Bremsstrahlung; Co^{60} photons; energy dependence; F centers; impurities; LiF (TLD); rate dependence; superlinearity; thermoluminescence; trap formation.

The total thermoluminescence light emission ("response") of LiF (TLD grade) was studied as a function of exposure and exposure rate, and as a function of photon energy. Co^{60} gamma rays and a broad spectrum of low-energy bremsstrahlung were employed. No rate dependence of the response was detected over the entire range of exposures and exposure rates employed (from about 10^2 R to 2×10^7 R, and from about 10^2 R/h to 7×10^6 R/h, respectively). This represents further evidence that centers other than F centers are involved in the thermoluminescence of LiF (TLD grade).

A comparison of the curves of response versus exposure for the two spectra confirms Naylor's findings that the superlinearity region is steeper for Co^{60} gamma radiation than for low-energy x rays, and reveals that the effect is indeed dependent on photon energy rather than on exposure rate. These findings are compatible with an explanation of superlinearity as being due to the formation of additional traps by the radiation proper. For exposures above those causing superlinearity, the difference in curve shape again disappears. Also, there is no dependence on energy of the location and height of the response maximum, which suggests that the inhibiting mechanism is independent of photon energy.

10922. Ehrlich, M., Lamperti, P. J., **Uniformity of high-energy electron-beam calibrations,** *Phys. Med. Biol.* **14,** No. 2, 305-314 (Sept. 1968).

> Key words: Calibration methods; facilities of users; ferrous sulfate; Fricke; high-energy electrons; NBS service; spectrophotometry; uniformity of dosimetry.

This is a report on the first year of operation of a new service offered by the National Bureau of Standards (NBS). Dosimeter units consisting of polystyrene blocks holding stoppered quartz spectrophotometer cells filled with Fricke solution are being shipped periodically to groups requesting assistance with absorbed-dose measurements in high-energy electron beams. As a check on their stability, all dosimeters are pre-exposed to about 6000 R (about 1.55 C/Kg) of ^{60}Co gamma radiation, and those with densities farthest from the average are excluded from all further work. The participants irradiate the dosimeters with electrons, using energies of their choosing between about 5 and 50 MeV, and doses between 4000 and 8000 rads (between 5 and 8×10^{-4} J/Kg) in water. The exposed dosimeters are returned to NBS for evaluation, along with unexposed controls. During the first year of operation, slightly more than one-half of the doses reported by the participants were within ±5 percent of the NBS dose interpretation, but some differed by as much as 30 percent or more. Only little correlation was found between a participant's method of beam calibration and agreement with NBS dose interpretation.

10923. Ehrlich, M., Placious, R. C., **Thermoluminescence response of CaF_2:Mn in polytetrafluoroethylene to electrons,** *Health Phys.* **15,** 341-350 (1968).

> Key words: CaF_2:Mn; electrons, 20 to 400 keV; energy dependence; fluence response; response per unit electron energy absorbed; sample-thickness dependence; thermoluminescence; thin foils; ^{60}Co gamma radiation.

Foils of powdered CaF_2:Mn in polytetrafluoroethylene, with thicknesses from 15 to 150 μm, were exposed to monoenergetic electrons having energies in the region between 20 and 400 keV. The thermoluminescence response of the foil was studied as a function of the energy and the fluence of the incident electrons, the foil thickness, and the electron energy absorbed in the foils. The dependence on electron energy of the response per unit fluence was found to change considerably with foil thickness, the maximum response occurring at approximately the energy of the incident electrons whose ranges are equal to the thickness of the foil layers. From the lowest incident-electron energy employed (20 keV) up to this energy (200 keV for the 150 μm layer), response per unit fluence increased linearly with electron energy. Therefore, response per unit energy fluence (in this energy range approximately equal to total energy absorbed in the foils) was independent of the energy of the incident electrons, at least within the large error of the experiment. The response per unit of electron energy absorbed also agreed, within the limits of experimental error, with that obtained for foils exposed to ^{60}Co gamma radiation.

10924. Eick, J. D., Hegdahl, T., **Segregation in dental gold casting alloys,** *J. Dental Res.* **47,** No. 6, Part 2, 1118-1127 (Nov.-Dec. 1968).

> Key words: Casting gold; composition; dental gold alloys; electron microprobe; grain reduction; grain size; segregation.

The purpose of this investigation was to establish a quantitative method for determining the degree of segregation in dental gold casting alloys. The electron microprobe was employed to analyze concentration differences. A line scan was used to determine the variations in concentration present in the alloy. The nature of the segregation was expressed by the coefficient of correlation and the coefficient of variation. Segregation occurred between Ag and Cu in the Type I alloys. In the Type II and III alloys Ag and Pd segregated together and opposed Cu, while Ag, Cu, and Pt opposed Pd in the Type IV alloys. Au and Zn did not appear to segregate to a significant degree with the other elements. The coefficient of variation was used to define the degree of segregation on a quantitative basis. The degree of segregation between the fine grained alloys and coarse grained alloys of the same type was not significantly different. Pd was found to have the highest degree of segregation, while Au and Pt segregated the least. As the concentration of Cu was increased in the alloy, the degree of segregation decreased.

10925. Eicke, W. G., **The zener diode, a working D-C voltage standard,** *1968 IEEE Intern. Convention Digest,* p. 71 (Mar. 1968).

Key words: Electrical measurements; instrumentation; standard cell; voltage standard; zener diode.

This is a summary of a Tutorial paper to be presented at the 1968 IEEE International Convention in New York, N.Y. in March 1968. The summary discusses zener diodes as a working D-C voltage standard.

10926. Eisenhart, C., Zelen, M., **Elements of probability,** Chapter 12 in *Handbook of Physics, Second Ed., Mathematics,* E. U. Condon and H. Odishaw, eds., Part 1, pp. 1-163 – 1-197 (McGraw-Hill Book Co., Inc., New York, N.Y., 1967).

Key words: Bayes' theorem; central limit theorem; characteristic function of a distribution; mathematical probability; mean values of random variables; probability distributions; probability inequalities; probability limit theorems; propagation of error; random variables; statistical distributions; tables of probability distributions; transformation of variables in probability distributions.

This chapter provides a concise exposition of the axiomatic definition of (mathematical) probability; of the theory of random variables and distribution functions in one, two, and *n* dimensions; of the properties of mean values of random variables and of characteristic functions, generating functions, and moments; of measures of location, dispersion, skewness and kurtosis of probability distributions; of weak and strong convergence in probability; of the central-limit theorem and its applications; and of the special properties of the normal, chi-square, Student's t, Snedecor's F, binomial, negative binomial, hypergeometric and Poisson-exponential distributions. The annotated bibliography of 132 entries serves as a guide not only to the principal textbooks, treatises, and monographs on probability theory and its applications, but also to authoritative individual tables of particular probability distributions as well as to general collections of probability and statistical tables.

10927. Enemark, E. A., Gallagher, A., **A Pockels cell light modulator for wide angle radiation,** *Rev. Sci. Instr.* **40,** No. 1, 40-41 (Jan. 1969).

Key words: Isotropic radiation; KDP light modulator; light modulator.

A Pockels cell light modulator which operates at radio frequencies is described. It transmits more isotropic radiation than other Pockels cell or water cell modulators that operate at these frequencies. In addition, the modulated light has less phase variation between different components of the radiation than do water cell modulators.

10928. Engen, G. F., **A method of calibrating coaxial noise sources in terms of a waveguide standard,** *IEEE Trans. Microwave Theory Tech.* **MTT-16,** No. 9, 636-639 (Sept. 1968).

Key words: Noise; noise calibration; radiometer.

The UHF and microwave portion of the radio frequency spectrum is characterized by the use of several different types of transmission lines, the most common being coaxial line and rectangular waveguide. A frequent and recurring problem is that of calibrating an item which is fitted with one type of output (or input) terminals, in terms of a "standard" having a different set of terminals or connector.

By an extension of certain techniques which were developed in an earlier paper on power calibration transfer, it is possible to make a similar comparison of noise sources. The procedure requires a suitable adaptor and a pair of measurements which are combined in such a way that the adaptor losses approximately cancel.

10929. Engen, G. F., **A method of determining the mismatch correction in microwave power measurements,** *IEEE Trans. Instr. Meas.* **IM-17,** No. 4, 392-395 (Dec. 1968).

Key words: Microwave measurements; mismatch; power measurement.

With the increasing demands for accuracy in microwave measurements, mismatch corrections are assuming an increased importance. In the application of a terminating type power meter, the appropriate mismatch factor involves the *complex* reflection coefficients of the generator, load, and power meter.

Instead of measuring the individual reflection coefficients, which usually calls for the use of a slotted line, this paper describes a directional coupler technique which obtains the mismatch factor directly.

10930. Ensign, T. C., Chang, T. T., **Low temperature optical-EPR sample probe using tunable coaxial coupling,** *Rev. Sci. Instr.* **40,** No. 2, 268-270 (Feb. 1969).

Key words: EPR-optical double resonance; low temperature; magnetic resonance (EPR); tunable coaxially-coupled microwave cavity.

An optical-EPR sample probe using tunable coaxial coupling, for use at fixed temperatures in the range 1-300 K, has been designed and constructed. It allows both critical coupling of the resonant cavity to the microwave system and good sample illumination, while minimizing thermal agitation.

10931. Ernst, M. H., **Transport coefficients from time correlation functions,** *Lectures in Theoretical Physics, Kinetic Theory,* **IXC,** 417-441 (Gordon and Breach Science Publ. Inc., New York, N.Y., 1967).

Key words: Cluster expansion method; dense gases; projection operator method; self diffusion coefficient; time correlation function; transport coefficient.

Transport coefficients are calculated for a classical dense gas using time correlation functions. In particular two formal methods are discussed both of which lead to a systematic expansion of the transport coefficients in powers of the density. One method is an application of the projection operator method developed by Zwanzig; the second one uses the cluster expansion technique of Green and Cohen. A comparison between the results of both methods is given.

10932. Evans, J. P., Sweger, D. M., **Immersion cooler for freezing ice mantles on triple-point-of-water cells,** *Rev. Sci. Instr.* **40,** No. 2, 376-377 (Feb. 1969).

Key words: Ice mantle; immersion cooler; triple-point cell.

This note describes a simple immersion cooler designed to freeze an ice mantle on the reentrant well of a triple-point-of-water cell. The cooler consists of a thin wall metal tube, closed at one end and connected to a condenser at the other, filled with a liquid of low boiling point. When the cooler is inserted in the well of the triple point cell and the condenser is chilled with dry ice and alcohol, the liquid-vapor phase transition extracts heat from the cell, producing a uniform ice mantle in 30 minutes.

10933. Evenson, K. M., Broida, H. P., Wells, J. S., Mahler, R. J., Mizushima, M., **Electron paramagnetic resonance absorption in oxygen with the HCN laser,** *Phys. Rev. Letters* **21,** No. 15, 1038-1040 (Oct. 7, 1968).

Key words: Electron paramagnetic resonance; HCN laser; molecular oxygen; Zeeman levels.

Paramagnetic resonance absorption between the $N=3, J=4, M=-4$ and $N=5, J=5, M=4$ levels of ground state O_2 was observed at the HCN laser frequency of 890, 759 ± 3 MHz in a 16,418 ± 1 gauss magnetic field. This is the first observation of absorption in a gaseous sample in which laser electron paramagnetic resonance techniques (LEPR) were used.

10934. Fano, U., Cooper, J. W., **Spectral distribution of atomic oscillator strengths,** *Rev. Mod. Phys.* **40,** No. 3, 441-507 (July 1968).

Key words: Absorption; light; oscillator strength; spectra distribution; x-ray.

Information on the spectrum of oscillator strength for neutral atoms in their ground states is surveyed with particular regard to recent progress in the far uv-soft x-ray range and to the theoretical interpretation of data from experiments and from numerical calculations. The analysis brings out numerous aspects of atomic mechanics and problems that remain unsolved. An effort is made to interconnect different theoretical approaches within the framework of the theory of atomic spectra.

10935. Farrar, T. C., Johannesen, R. B., Coyle, T. D., **Magnetic nonequivalence in the high-resolution NMR spectra of diborane,** *J. Chem. Phys.* **49,** No. 1, 281-285 (July 1, 1968).

Key words: Boron; computer-calculated spectra; diborane; magnetic non-equivalence; proton magnetic resonance; spin coupling.

Proton and boron-11 nuclear magnetic resonance spectra of ^{11}B-enriched neat diborane have been measured over the temperature range from −7 to −60 °C. The terminal-proton resonance and the ^{11}B spectrum exhibit partially-resolved fine structure which arises from the magnetic non-equivalence of the terminal protons and of the boron nuclei due to long-range spin coupling. Spectra were calculated which agree quite well with the observed spectra and result in a reasonably accurate determination of the magnitudes and most of the relative signs of the various coupling constants. These values are: $J_{BB}=\mp 5$ Hz, $J_{BH_b}=+47.0$ Hz, $J_{BH_t}=+133$ Hz, $J'_{BH_t}=+4$ Hz, $|J_{H_tH_b}|=7.2$ Hz, $J_{H_tH_t}$(trans or cis)$=\pm 14$ Hz, $J_{H_tH_t}$(cis or trans)$=\pm 6$ Hz, $|J^{gem}_{H_tH_t}|<3$ Hz, $\delta(H_t-H_b)=-4.50$ ppm.

10936. Fatiadi, A. J., **Acylation of tetrahydroxy-p-benzoquinone,** *J. Chem. Eng. Data* **13,** No. 4, 591-593 (Oct. 1968).

Key words: Acetates; benzenehexol; disproportionation; esters; rhodizonic acid; tetrahydroxyquinone.

Procedures are described for preparation of previously unreported di- and tetraacetates of tetrahydroxyquinone. Chemical proof is presented for disproportionation of tetrahydroxyquinone into benzenehexol (hexahydroxy-benzene) and rhodizonic acid in a slightly basic solution. By use of this reaction, a series of acyl derivatives of benzenehexol has been prepared; certain esters of tetrahydroxyquinone also disproportionate in a slightly basic medium.

10937. Fatiadi, A. J., **Bromine oxidation of inositols for preparation of inosose phenylhydrazones and phenylosazones,** *Carbohydrate Res.* **8,** 135-147 (1968).

Key words: Bromine; inositol; inosose phenylhydrazone; inosose phenylosazone; mutarotation; oxidation.

The application of bromine oxidation of inositols to give inososes, followed by conversion of the latter into phenylhydrazones or phenylosazones, is described. The diketone from *myo*-inositol gives a phenylosazone in 22-30 percent yield, and L-inositol gives a monoketone phenylhydrazone (12 percent yield) and a diketone phenylosazone (28 percent yield); the corresponding enantiomorphs were obtained in 8 and 29 percent yield, respectively. The diketone from quebrachitol yields a new phenylosazone (29 percent yield) and no monoketone was isolated. Pinitol gave a new diketone phenylosazone (10-15 percent yield) which showed rapid mutarotation in 1:1 (v/v) ethanol—*p*-dioxane. In addition, a new phenylosazone has been obtained from DL-*epi*-inosose-2 phenylhydrazone. (+)-*proto*-Quebrachitol (from acorns) has been converted into a phenylosazone (20 percent yield). *myo*-Inositol has been converted by bromine oxidation into DL-*xylo*-pentahydroxy-2-cyclohexen-1-one in low yield.

10938. Fatiadi, A. J., **Esters of benzenepentol(pentahydroxybenzene),** *J. Chem. Eng. Data* **14,** 118-119 (1969).

Key words: Acetic anhydride; aromatization; benzenepentol (pentahydroxybenzene); ester; methyl sulfoxide; *myo*-inositol.

Several esters of benzenepentol (pentahydroxybenzene) have been prepared by one-step aromatization of *myo*-inositol, and characterized.

10939. Fatiadi, A. J., **Evidence for a chair conformation of certain osotriazoles of inositols,** *Chem. Ind.* **19,** 617-619 (May 10, 1969).

Key words: Computer; diketoinositol phenylosotriazole; half-chair conformation; mercuric acetate; p.m.r. spectra; symmetrical.

D-, L-, and DL-Inositol phenylosotriazoles were prepared with a new reagent, namely, mercuric acetate. Proton magnetic resonance spectra showed the ring protons as an AA′BB′ system. The favored conformation of the compounds as tetraacetates in solution was found to be that of the half-chair. The observed ring proton p.m.r. spectrum of the DL-tetraacetate was found to be in good agreement with that calculated by computer.

10940. Fatiadi, A. J., **Nature of a colored by-product found in crude inosose phenylosazones,** *Carbohydrate Res.* **9,** 177-185 (1969).

Key words: Crude inosose; enols; formation; inositol; oxidation; phenylosazone.

It has been shown that the crude inosose phenylosazones from D- and L-*myo*-inosose-1, *myo*-inosose-2, and DL-*epi*-inosose-2 contain a red, enolic impurity having a known structure, namely, *xylo*-2-oxo-1,3-bis(phenylhydrazono)cyclohexane-4,5,6-triol. Similarly, the crude inosose phenylosazones from quebrachitol (1-*O*-methyl-*levo*-inositol) and pinitol (5-*O*-methyl-*dextro*-inositol) also contain a colored, enolic impurity having a structure analogous to that obtained from the above nonmethylated inosose phenylosazones.

10941. Feldman, A., Horowitz, D., **Dispersion of the piezobirefringence of GaAs,** *J. Appl. Phys.* **39,** No. 12, 5597-5599 (Nov. 1968).

Key words: Absorption edge; birefringence; dispersion of piezobirefringence; gallium arsenide; nonlinear piezobirefringence; photo-elasticity; piezobirefringence; piezo-optical coefficients; resonance-photoelasticity; stress-birefringence.

The piezobirefringence of GaAs shows a large anomalous dispersion near the absorption edge and exhibits a nonlinear stress dependence. The coefficient $\pi_{11}-\pi_{12}$ reverses sign. Lowering the temperature from 298 K to 77 K shifts the dispersion curves +0.088 eV which is approximately equal to the shift of the energy gap with temperature. These effects, which have not been observed previously in GaAs, are related to the stress dependence of transitions associated with the absorption edge and resonance photo-elasticity described by Kaplyanskii and Lozovskaya.

10942. Feldman, A., Horowitz, D., **Stress-induced dichroism at the absorption edge of $SrTiO_3$,** *Solid State Commun.* **6,** 607-612 (1968).

Key words: Absorption edge; dichroism; rotary transmission method; selection rules; $SrTiO_3$; uniaxial stress.

The stress-induced dichroism at the absorption edge of $SrTiO_3$ has been measured at room temperature by the rotary transmission method. Stress- and strain-absorption coefficients were determined for the range of photon energies 3.15 – 3.22 eV. Our results, together with the selection rules derived by Casella, cast doubt upon the assignment of the absorption edge of $SrTiO_3$ to the transition $X_{5'} \rightarrow X_3$.

10943. Florin, R. E., Sicilio, F., Wall, L. A., **The paramagnetic species from titanous salts and hydrogen peroxide,** *J. Phys. Chem.* **72,** No. 9, 3154-3161 (Sept. 1968).

Key words: Electron spin resonance; free radicals; hydroperoxyl radical; hydroxyl radical; titanic complexes; titanium trichloride.

The radical species giving ESR spectra on mixing titanous salts and hydrogen peroxide cannot be hydroxyl as formerly supposed. Observed kinetics are inconsistent with simple generation and disappearance schemes. In organic substrate mixtures the species increases with time while organic radicals decrease. The two "hydroxyl" species are probably forms of HO_2 complexed with Ti^{4+}. The rate constant k_1 of the initial reaction $Ti^{3+} + H_2O_2 \rightarrow OH + OH^- + Ti^{4+}$ is estimated as equal to or greater than 200 M^{-1} sec^{-1} from appearance rate of $Ti^{4+} \cdot H_2O_2$. and 800-1800 M^{-1} sec^{-1} from indirect analysis of radical concentration-time curves.

10944. Flynn, D. R., Watson, T. W., **High temperature thermal conductivity of soils,** (Proc. 8th Conf. Thermal Conductivity, Purdue University, West Lafayette, Ind., Oct. 7-10, 1968), Chapter in *Thermal Conductivity,* pp. 913-939 (Plenum Press Inc., New York, N.Y., Apr. 1969).

Key words: Conductance; conductivity; heat transfer; nuclear safety; soils; temperature; thermal conductance; thermal conductivity.

A description is given of an apparatus which has been used to measure the thermal conductivity of soil samples at hot-side temperatures to 1600 °C. The method utilizes radial heat flow in a hollow cylinder 1.3 cm inside diameter, 7.6 outside diameter, and 43 cm long. The outside of the sample is maintained near room temperature while the inside is heated to the desired temperature by means of a specially designed heater. The mathematical analysis of the method is given. Thermal conductivity values are given for nine natural or artificial soils which are representative of most of the subsoils found on earth.

The method used shows considerable promise as a means of rapid and cheap generation of engineering data on the thermal conductivity of loose-fill materials.

10945. Folman, M., Klein, R., **Second layer migration with trapping on first layer sites: hydrogen, nitrogen, and carbon monoxide on tungsten,** *Surface Sci.* **11,** No. 3, 430-442 (Aug. 1968).

Key words: Carbon monoxide; field emission; hydrogen; nitrogen; second layer migration; tungsten.

Second layer migration of hydrogen, nitrogen, and carbon monoxide on tungsten is observed with a field emission microscope. The initial deposition on the tungsten surface at 4.2 °K is made with molecular beams with the tungsten emitter axis perpendicular to the beam direction. The migration of the deposit is effected at temperatures far below those for which the chemisorbed layer is mobile. The shapes of the sharp line boundaries as the second layer migrates over the chemisorbed layer and onto the clean tungsten substrate are quite different for the three gases observed. It is proposed that, in addition to the barrier effects of certain planes of the tungsten, the density of trap sites on the clean surface dictates the boundary configuration. The trap site densities differ for the different gases.

10946. Foster, B. E., Blaine, R. L., **A comparison of ISO and ASTM tests for cement strength,** *Am. Soc. Testing Mater. Spec. Tech. Publ.* **441,** 33-60 (1968).

Key words: Cement strength; ISO cement standards; sand gradation; testing sand.

A comparison of compressive strength tests of 6 portland cements shows that the proposed ISO procedure gave results from 25 to 95 percent higher than ASTM Method C109, depending upon strength level, test age, and cement fineness. The testing sand is seen as the major problem in developing a truly international standard for cement strength, and it is concluded that the selection of equivalent sands is complicated by the prescribed mechanical compaction, which causes forced bleeding. ISO tests using Ottawa-type, round-grain sands are described.

10947. Fraction, G. F., Walker, J. C., Tauber, S. J., **Connection tables from Wiswesser line notation: A partial algorithm,** (Proc. Wiswesser Line Notation Meeting, Army Chemical Information and Data Systems Program, Edgewood Arsenal, Aberdeen, Md., Oct. 6-7, 1966, Spec. Publ. 400-8), *AD665397,* pp. 139-195 (Clearinghouse for Federal Scientific and Technical Information, Springfield, Va., Jan. 1968, $3.00).

Key words: Acyclic; benzene; chemical structure notations; connection tables; contractions; ring system; syntax analysis; transformation algorithm; Wiswesser.

An algorithm has been developed for transforming certain types of Wiswesser organic structure notations into connection tables. Acyclic and benzene structures are treated, and provision has been made for all of the types of contractions used by the Wiswesser notation system. A separate algorithm is presented for treating linearly fused ring aggregates. A syntax has been developed to describe those portions of Wiswesser notations which refer to non-benzene ring systems.

10948. Freeman, D. H., Paulson, R. A., **Chemical microstandards from ion exchange resin,** *Nature* **218,** 563 (1968).

Key words: Analytical detection limits; ion exchange resins; measurements; microstandards; standards.

10949. Frisch, R. C., Forman, R. A., **Nuclear magnetic resonance of Ti in Ti-H systems,** *J. Chem. Phys.* **48,** No. 11, 5187-5190 (June 1, 1968).

Key words: Hydrides; hydrogen; nuclear magnetic resonance; titanium.

The nuclear magnetic resonance spectrum of $^{47,49}Ti$ in powder samples of metallic titanium hydride TiH_x has been studied over the range of hydrogen concentrations corresponding to $1.7 \leq x \leq 2.0$. For TiH_2 the Knight shift is found to be $+0.26 \pm .04$ percent, and there is no change in the Knight shift as a function of hydrogen concentration over the range studied. The titanium resonance in all samples was quite broad, 20 Oe, so that the lines from the two isotopes were not resolved. As a function of hydrogen concentration, lineshape was found to remain constant, but a rapid decrease of line intensity was noted.

In order to investigate the possibility of magnetic ordering suggested by earlier studies of the magnetic susceptibility of TiH_2, studies of the magnetic field dependence and temperature dependence of the resonance were also performed. No dependence of Knight shift or lineshape on magnetic field was observed over the range of 9.0 to 15.0 kOe. No changes in Knight shift or lineshape were observed in the temperature region from 170 to 525 °K, thoroughly encompassing the region of the magnetic susceptibility maximum at approximately 300 °K. These results strongly suggest that the cause of the maximum in the magnetic susceptibility is not magnetic ordering.

Results on hydrogen and deuterium resonances in these samples are also reported.

10950. Gadsden, M., **Airglow,** *Encyclopedia of Atmospheric Sciences and Astrogeology,* R. W. Fairbridge, ed., pp. 8-10 (Reinhold Publ. Co., New York, N.Y., 1967).

Key words: Airglow; atmosphere.

A short article on the general topic of the airglow.

10951. Gadsden, M., **Airglow motions,** *International Dictionary of Geophysics* **I,** 50-56 (1967).

Key words: Airglow emissions; atmosphere; nightglow emission.

A critical review is presented of the available information on movements of the high atmosphere deduced from observations of airglow emissions. Some of the first results of an analysis to extend knowledge of movements disclosed by nightglow emissions are presented.

10952. Gallagher, A., **Excitation transfer in nearly adiabatic thermal collisions,** *Phys. Rev.* **179,** No. 1, 105-110 (Mar. 5, 1969).

Key words: Cs; excitation-transfer collisions; He; Rb; Stuckelberg Equation.

Some sources of error that arise in the use of Stuckelberg's formula for excitation-transfer calculations are pointed out. To demonstrate these difficulties, Stuckelberg's formula for non-crossing levels is used to calculate adiabatic excitation-transfer cross sections for He^*, Rb^*, and Cs^* collisions with inert gases and for $Alkali^*$-Alkali collisions. In contradiction with another (erroneous) calculation for He^*, these cross sections generally disagree with experimental observations by orders of magnitude. The reasons for this, and some conditions for the validity of this method of calculating adiabatic cross sections are given.

10953. Gardner, T. V., Jr., Dickson, G., Kumpula, J. W., **Application of diffraction gratings to measurement of strain of dental materials,** *J. Dental Res.* **47,** No. 6, Part 2, 1104-1110 (Nov.-Dec. 1968).

Key words: Dental amalgam; dental materials; diffraction gratings; modulus of elasticity; strain gage; stress-strain measurement.

A system for measurement of strain by means of diffraction gratings ruled on small specimens has been applied to dental materials. The method gives a rapid response to stress, is effective over very short gage lengths, and does not require the attachment of a measuring device to the specimens. Gratings with a spacing of approximately 16,000 lines per inch are ruled on polished specimens. When the specimen is stressed, this spacing is changed resulting in a change in the angle of diffraction of a beam of light directed onto the grating. The change in angle of diffraction is measured by means of photomultiplier tubes behind "V" slits, and from the change in angle, the magnitude of the strain is calculated.

10954. Garfinkel, S. B., Mann, W. B., **A method for obtaining large numbers of measured time intervals in radioactive decay,** *Intern. J. Appl. Radiation Isotopes* **19,** No. 9, 707-709 (Sept. 1968).

Key words: Multichannel multiscaler analyzer; Poisson distribution; radioactive decay.

A method is described for the acquisition of large numbers of measured time intervals between consecutive alpha-particle emissions in radioactive decay. A multichannel multiscaler analyzer was used in a modified multiscaler mode. The data are to be analyzed to see if they conform to a Poisson distribution.

10955. Gatterer, L. E., Bottone, P. W., Morgan, A. H., **Worldwide clock synchronization using a synchronous satellite,** *IEEE Trans. Instr. Meas.* **IM-17,** No. 4, 372-378 (Dec. 1968).

Key words: Atomic clocks; clock synchronization; geodesy; ionospheric propagation; navigation; satellite tracking; VHF satellite transponder.

An experiment performed in late 1967 is reported in which the synchronization of widely separated atomic clocks was investigated. One-way VHF radio transmissions from the reference clock were relayed to remote clocks using a geo-stationary satellite transponder. This is in contrast to experiments described in the literature where two-way satellite communications were used. The problem of measuring the time difference between a remote clock and a reference clock using one-way radio transmissions reduces to the problem of predicting the propagation delay experienced by the radio wave. For example, the accuracy with which a user's clock can be set using WWV is limited by the predictability of the propagation delay from WWV to the user's receiver. The principal advantage of using a geo-stationary satellite transponder is that the radio path is predominately a free space, line-of-sight path, which is predictable. Those portions of the path for which radio refractive index is variable constitute only a small percentage of the total path. In this experiment predicted values of propagation delay were compared to measured values. The accuracy of predictability, and hence of clock synchronization, was 10 μsec. or 60 μsec., depending on the prediction method used. The technique may offer an alternative to transporting atomic standards to geodetic and tracking stations around the world fulfilling their clock synchronization requirements. Several methods were used to check the time differences between the station clocks. These included transported atomic clocks, a satellite technique using two-way communications, and a one-way microwave link using the moon as a passive reflector.

10956. Gautier, T. N., Zacharisen, D. H., **Use of space and time correlations in short-term ionospheric predictions,** *First Ann. IEEE Commun. Convention,* pp. 671-676 (June 1965).

Key words: Ionospheric prediction; linear regression; space and time correlations; sunspot cycle trends.

A scheme for short-term ionospheric prediction based on standard methods of linear regression and least squares is presented. Emphasis is placed on the use of current observations of the ionospheric characteristics themselves in the prediction of their future values or their values at other places. Predictions of monthly median values for each hour of the day of certain characteristics, based on diurnal, seasonal, and sunspot cycle trends, and their geographical variations, have been made for many years. The short-term prediction scheme described here applies to the departures of daily values for a particular hour of the day from the monthly median for that hour. The prediction equation, adjusted for a minimum mean square prediction error, involves the correlation coefficients of the departures at different times of the day at the same station as well as the correlation coefficients for the departures at different stations. Correlation coefficients computed from some actual observations are presented to show how the correlation coefficient decreases with time separation of the observations at the same station, and with distance separation in the case of observations made simultaneously at different stations. In the case of time separation of individual stations, the median correlation coefficient for the stations studied fell below 0.7 at a time separation of about 2 hours, and below 0.5 at about 4 hours. In the case of distance separation, the median correlation coefficient for simultaneous observations fell below 0.7 at a distance separation of about 1000 km and below 0.5 at about 2000 km.

10957. Gebbie, K. B., Thomas, R. N., **Non-LTE diagnostic stellar spectroscopy. I. Conceptual and analytical background,** *Astrophys. J.* **154,** No. 1, 271-283 (Oct. 1968).

Key words: Collisional processes; LTE; radiation field; state parameters; stellar atmosphere; thermodynamic equilibrium.

Seeking a non-restrictive determination of the state of a stellar atmosphere, defined as the occupation numbers describing the energy states of the directly-observable parts of the star, we delineate those regions where thermodynamic equilibrium state parameters can be adopted for internal energy states either because collisional processes predominate or because the radiation field satisfies certain homogeneity conditions. The boundary values for the state parameters of the LTE stellar interior must generally be determined in a lower atmospheric region satisfying these homogeneity conditions on the radiation field; spectroscopic diagnostics generally refer to an upper atmospheric region not satisfying the homogeneity conditions. We summarize an approach to specifying the state parameters describing these latter regions, and the analytical basis for determining their values. This paper then provides the background for the specific applications in following papers.

10958. Gebbie, K. B., Thomas, R. N., **Non-LTE diagnostic stellar spectroscopy. II. On the Schuster mechanism for the production of emission lines,** *Astrophys. J.* **154,** No. 1, 285-296 (Oct. 1968).

Key words: Collisional processes; LTE; radiation field; state parameters; stellar atmosphere; thermodynamic equilibrium.

We investigate the conditions under which the Schuster mechanism can produce emission lines. We consider Schuster's original formulation, together with Milne's modification and a general non-LTE formulation. We conclude that while emission lines may result in particular circumstances, it is unlikely that observations of bright lines can be interpreted by this mechanism.

10959. Geltman, S., **Topics in atomic collision theory, 30,** 247 pages (Academic Press Inc., New York, N.Y., 1969).

Key words: Atom-atom collisions; electron-atom collisions; static field scattering.

This book is based on a course of graduate lectures given at the University of Colorado, Boulder, Colorado (U.S.A.) and at University College in London, England. It concerns the application of quantum scattering theory to low-energy atomic collision phenomena. It is divided into the three parts—static field scattering, electron-atom collisions, and atom-atom collisions—and there are ten sections in each of these parts.

10960. Ginnings, D. C., **Introduction,** Chapter 1 in *Experimental Thermodynamics,* **Vol. I,** *Calorimetry of Nonreacting Systems,* J. P. McCullough and D. W. Scott, eds., pp. 1-13 (Butterworth & Co., London, England, 1968).

Key words: Definitions; heat constants; heat units; methods of calorimetry; standard reference substances; symbols; terminology.

10961. Ginnings, D. C., West, E. D., **Principles of calorimetric design,** Chapter 4 in *Experimental Thermodynamics,* **Vol. I,** *Calorimetry of Nonreacting Systems,* J. P. McCullough and D. W. Scott, eds., pp. 85-131 (Butterworth & Co., London, England, 1968).

Key words: Design principles; heat leak errors; heat transfer; temperature gradients in calorimeters; tempering of leads.

10962. Ginnings, D. C., Stimson, H. F., **Calorimetry of saturated fluids including determination of enthalpies of vaporization,** Chapter 11 in *Experimental Thermodynamics,* **Vol. 1,** *Calorimetry of Nonreacting Systems,* J. P. McCullough and D. W. Scott, eds., pp. 395-420 (Butterworth & Co., London, England, 1968).

Key words: Adiabatic calorimetry; heat capacity; heats of vaporization.

10963. Glasgow, A. R., Jr., Ross, G. S., **Cryoscopy,** Chapter 88 in *Treatise on Analytical Chemistry, Part I, Theory and Practice,* I. M. Kolthoff, P. J. Elving, E. B. Sandell, eds., **8,** 4991-5083 (Interscience Publ., New York, N.Y., 1968).

Key words: Calorimetry; cryoscopy; dilatometry; freezing; heat of fusion; melting; melting point molecular weight; purity.

The general principles of cryoscopy as applied to purity analysis, molecular weight determination, and phase investigation are described. The phase rule as it applies to both ideal and non-ideal solutions is discussed. The uses and descriptions of various cryoscopic apparatus are described in some detail. The use of resulting data in the calculation of melting point, sample purity, molecular weight, heat of fusion, heat capacity, and phase diagrams is discussed. The chapter primarily centers around the authors' own work in the field, but includes a bibliography of 175 references.

10964. Golub, S., Steiner, B., **Photodetachment of $[OH(H_2O)]^-$,** *J. Chem. Phys.* **49,** No. 11, 5191-5192 (Dec. 1, 1968).

Key words: Electron affinity; negative ion; photodetachment; water.

The relative photodetachment cross section of $H_3O_2^-$ has been measured from threshold near 2.95 eV to 4 eV. The continuously rising cross section is consistent with detachment to a repulsive state of the neutral H_3O_2. An upper limit on the weakest bond is shown to be 1.2 eV.

10965. Grabner, L., **Photoluminescence in $SrTiO_3$,** *Phys. Rev.* **177,** No. 3, 1315-1323 (Jan. 15, 1969).

Key words: Energy transfer; infrared emission; lattice phonons; photoluminescence; strontium titanate; visible emission.

At 77 K photoluminescence from nominally pure, 0.05 percent Sm-doped, and 0.005 percent Cr-doped $SrTiO_3$ give identical spectra in the infrared (I.R.) with an intensity ratio of 1:20:400, respectively. In undoped and Sm-doped specimens the intensity of emission is vanishingly weak at 4 K in constrast to Cr-doped $SrTiO_3$ in which it is practically unchanged relative to that at 77 K. At 77 K the spectrum consists of a narrow line at 1.5625 eV of half-width 0.5×10^{-3} eV which we identify as the zero-phonon line and 31 satellite lines which are shown to be vibronics due to lattice phonons from the center and edge of the Brillouin zone. At 4 K the zero-phonon is a doublet. Comparison with the reported lattice phonon spectrum is satisfactory. In addition, the data suggest the energy of several zone boundary phonons which have not been reported.

In spite of identical emission spectra, undoped, Sm-doped, and Cr-doped specimens have different excitation spectra. This suggests energy transfer from Sm or Cr to a tightly bound center, isolated from the electronic energy bands, such as typically arise from rare earth ions in ionic crystals. It is suggested that the center is an intrinsic defect or intrinsic per se, viz., an exciton.

In undoped $SrTiO_3$ an emission band in the visible—2.175 eV (77 K), 2.475 eV (4 K)—and its excitation spectrum are reported. The temperature dependence of both are anomalous. In contrast to the infrared emission, it is broad (half-width 0.63 eV) and structureless. Application of a dc electric field ~ 100 V/cm, at 4 K, induces oscillations in time of the visible emission, a property not shared by the I.R. emission.

10966. Green, M. S., **Generalized Ornstein-Zernike approach to critical phenomena,** *J. Math. Phys.* **9,** No. 6, 875-890 (June 1968).

> Key words: Critical phenomena; entropy-energy-volume; fluctuations; fundamental maximum principle; generalized Ornstein-Zernike equation; molecular distribution functions; Ornstein-Zernike theory; Percus-Yevick equation; phase transitions; potentials of average force.

A generalization of the Ornstein-Zernike integral equation is derived and suggestions are made about a possible application to an improved theory of critical phenomena. A fundamental maximum principle of statistical mechanics is used to place the generalized equation in the context of phase transitions and critical points. The equation is a relationship between a generalized correlation matrix by means of which the average fluctuation product of any two sum functions may be expressed and a generalized direct correlation matrix which is the second functional derivative of the functional in the maximum principle. The existence of a critical eigenvector of the direct correlation matrix is proposed and three physical meanings of this vector are given. An explicit formula for the direct correlation matrix is given and is used to derive two asymptotic properties. This formula exhibits an unexpected relationship between the generalized Ornstein-Zernike equation and the Percus-Yevick equation.

10967. Haber, S., Osgood, C. F., **On a theorem of Piatetsky-Shapiro and approximation of multiple integrals,** *Math. Comput.* **23,** No. 105, 165-168 (Jan. 1969).

> Key words: Approximation; Banach-Steinhaus Theorem; Fourier Series; multiple integrals; number theory; numerical analysis; periodic functions; quadrature.

Quadrature formulas are derived for certain classes of functions of several variables having absolutely convergent Fourier Series. A limitation on formulas of the type considered is proven.

10968. Halford, D., Wainwright, A. E., Barnes, J. A., **Flicker noise of phase in RF amplifiers and frequency multipliers: characterization, cause, and cure,** *Proc. 22nd Annual Symp. Frequency Control, Atlantic City, New Jersey, Apr. 22-24, 1968,* pp. 340-341 (Solid State and Frequency Control Division, Electronic Components Laboratory, U.S. Army Electronics Command, Fort Monmouth, New Jersey, Apr. 1968).

> Key words: Atomic frequency standards; capacitor noise; cesium beam; flicker phase noise; frequency multipliers; frequency standards; hydrogen maser; negative feedback; noise; phase noise; RF amplifiers; transistor noise.

10969. Hall, J. L., **The laser absolute wavelength standard problem,** *IEEE J. Quantum Elect.* **QE-4,** No. 10, 638-641 (Oct. 1968).

> Key words: Laser wavelength standards; saturated molecular absorption; wavelength stabilization.

Stabilized lasers usually exhibit systematic frequency shifts larger than their resettability; this phenomenon is illustrated well by the 6328 Å Helium Neon laser. We describe a Lamb-dip stabilized laser which operates at 1.15259 microns in pure, low pressure (0.12 torr) neon. Optical heterodyne experiments indicate an accuracy exceeding 1 part in 10^9; short and medium term precisions of $1:10^{10}$ are easily achieved. We also report the successful operation of a wavelength reference based on the saturation of sharp molecular absorption. In the first experiments the P(7) line of the ν_3 band of methane is saturated inside the cavity of a 3.39 micron Helium-neon laser. The saturation maximum at molecular line center produces an "emission" feature whose linewidth is less than 5 parts in 10^9. The pressure-induced offset is expected to be less than 1 part in 10^{10}. Size scaling is expected to improve these first results by at least 1 decade.

10970. Haller, W., Macedo, P. B., **The origin of phase connectivity in microheterogeneous glasses,** *Phys. Chem. Glasses* **9,** No. 5, 153-155 (Oct. 1968).

> Key words: Connectivity of microphases; fluctuation theory; glass; intersecting growth theory; microheterogeneous glass; spinoidal decomposition theory.

Recently published electron micrographic studies have shown that microheterogeneous glasses with interconnected phases can form from early stages which consist of randomly distributed isolated spheres. These observations lend support to the previously postulated Intersecting Growth Theory, and not to the Spinoidal Decomposition Theory. While a classic diffusion model predicts that the terminal growth rate at approaching surfaces of growing spheres becomes infinitely small due to diffusional depletion of the separating matrix, the experimental facts do not show any such limitations since the approaching growth fronts join rapidly. Various mechanisms are discussed by which a finite joining-rate can be achieved. A mechanism is suggested which is based upon the fact that the classic boundary concept of diffusion is not anymore applicable to bodies of small magnitudes and has to be replaced by the concept of a transitional fluctuating boundary. From ultrasonic and electron microscopic evidence it is estimated that the fluctuations in the investigated systems are of the order of 50 Å.

It is furthermore shown that for systems having close to equal volume fraction the criterion for the terminal formation of an interconnected network or of isolated spheroids will be the nucleation density.

10971. Hanley, H. J. M., Childs, G. E., **Interim values for the viscosity and thermal conductivity coefficients of fluid He^4 between 2 and 50 K,** *Cryogenics* **9,** No. 2, 106-111 (Apr. 1969).

> Key words: Corresponding states; Enskog theory; helium-four; kinetic theory; quantum fluid; thermal conductivity; viscosity.

We discuss the estimation of viscosity and thermal conductivity coefficients of He^4 between 2 and 50 K for densities up to 0.2 g/cm^3. The literature is reviewed and data sources listed. Interim estimates of the coefficients are given based on limited experimental data, dilute gas kinetic theory, the Enskog theory, and corresponding states.

10972. Hanley, H. J. M., McCarty, R. D., Sengers, J. V., **Density dependence of experimental transport coefficients of gases,** *J. Chem. Phys.* **50,** No. 2, 857-870 (Jan. 15, 1969).

> Key words: Correlation; density dependence; kinetic theory; least squares analysis; logarithmic expansion; thermal conductivity; viscosity.

We analyze experimental transport data for several gases as a function of density and temperature. Necessary conditions are proposed to check if the data are consistent with a given density function at fixed temperature. It is found that the theoretically suggested density function, which involves terms logarithmic in the density, satisfies the conditions for the data examined in the temperature and pressure ranges considered. A power series in the density does not. Based on the analyses, first density coefficients of thermal conductivity and viscosity are reported, together with an estimate of their precision, at reduced temperatures up to $T^* \approx 30$.

10973. Hardy, S. C., Coriell, S. R., **Morphological stability and the ice-water interfacial free energy,** *J. Crystal Growth* **3,** No. 4, 569-573 (1968).

Key words: Cylinder; heat flow; ice; interfacial free energy; perturbations; stability; surface tension; water.

The growth rates of slightly perturbed single crystal ice cylinders in supercooled water have been measured. Using morphological stability theory, the ice-water interfacial free energy is calculated from the experimental observations. A value of 0.021 J/m^2 (21 erg/cm^2) is obtained. This is in good agreement with values previously obtained from nucleation experiments.

10974. Hardy, S. C., Coriell, S. R., **Morphological stability of a growing cylindrical crystal of ice,** *J. Appl. Phys.* **39,** No. 7, 3505-3507 (June 1968).

Key words: Cylinder; heat flow; ice; morphology; perturbations; stability; surface tension; water.

The morphological stability of an ice cylinder growing radially into slightly supercooled water is studied. The experimental results are in agreement with theory.

10975. Harris, W. P., Roberts, D. E., **New standard reference dielectric specimens at NBS,** *Proc. 1968 Annual Report Conf. Electrical Insulation and Dielectric Phenomena, Oct. 21-23, 1968, Buck Hill Falls, Pa.,* pp. 80-84 (Natl. Acad. Sci.—Natl. Res. Council, Washington, D.C., 1969).

Key words: Dielectric constant standards; fluorinated ethylene-propylene; fluorinated polymers; precise dielectric measurements; standard dielectric; standard of dielectric constant; standard reference materials.

A number of specimens of FEP (fluorinated ethylene-propylene copolymer) have been prepared and measured by the Polymer Dielectrics Section of NBS. Several diameters and thicknesses are available. Values of dielectric constant, dissipation factor and thickness are supplied with each specimen.

All values are obtained from two-fluid, three-terminal measurements. The estimated uncertainty of the dielectric constant and thickness measurement is ±0.05 percent. The dissipation factor is accurate to within about $\pm 10 \times 10^{-6}$. (This is a low-loss material, with dissipation factor about 55×10^{-6} at 1 kHz.)

These specimens are expected to remain mechanically and electrically stable over a long period of time, and to be relatively free from changes due to humidity. They will not have to be kept in a dessicator.

The technique of measurement is discussed, and data are presented to support the accuracy claim.

10976. Hartman, W. J., **Feasibility of communication with a satellite by means of tropospheric scatter,** *IEEE Trans. Commun. Technol.* **COM-14,** No. 3, 251 (June 1966).

Key words: Radio horizon; satellite; tropospheric scatter.

Theoretical methods are developed for predicting the transmission loss over a tropospheric scatter path from a point on the earth to a satellite. The results indicate that presently available equipment allows reliable communication to only very slightly beyond the radio horizon. Some of the difficulties encountered in designing experiments to test the theoretical predictions are investigated.

10977. Hein, R. A., Cox, J. E., Blaugher, R. D., Waterstrat, R. M., **Superconducting behavior of A-15 compounds,** *Solid State Commun.* **7,** 381-384 (1969).

Key words: A-15 type phases; atomic ordering; beta-tungsten compounds; critical magnetic fields; critical temperatures; superconductors.

Superconductivity has been discovered in the A-15 type compounds $V_{1-x}Ni_x$, V_3Pd and $Ta_{85}Pt_{15}$ and a new feature has been observed in the T_c versus e/a correlation for these compounds. Evidence is presented to show that the anomalously low value of T_c for V_3Pd probably results from magnetic interactions which tend to depress T_c. Differences in the behavior of 3d compounds as compared with 4d compounds can be explained by the theory of McMillan.

10978. Heinrich, K. F. J., **Common sources of error in electron probe microanalysis,** *Advan. X-ray Anal.* **11,** 40-55 (1968).

Key words: Absorption correction; atomic number correction; electron probe microanalysis; fluorescence correction; quantitative analysis.

In order to reduce the error of quantitative electron probe microanalysis, error sources in the preparation and measurement of specimens and standards must be minimized. These sources of error are described, and literature references for detailed study are given. A critical analysis is made of 150 analytical measurements of binary specimens previously discussed by Poole and Thomas. It is shown that the cases of serious errors reported by these authors are mainly due to poorly characterized or measured specimens and in some cases to the omission of characteristic fluorescence corrections. If these sources of error are eliminated, a much more favorable error distribution can be obtained through relatively simple correction calculations. Further progress in quantitative microprobe analysis is dependent upon measurements using well-controlled conditions and standard materials of experimentally proven micro-homogeneity and reliably determined composition.

10979. Heinrich, K. F. J., **Electron probe microanalysis: a review,** *Appl. Spectry.* **22,** No. 5, Part 1, 395-403 (Sept.-Oct. 1968).

Key words: Analysis; electron probe; microanalysis; spectrometry; x-rays.

This review covers the development of electron probe microanalysis in the last ten years. After a brief description of the instrument, the following subjects are discussed: progress in instrumentation, progress in the theory of quantitative analysis, and the future development of microprobe analysis.

10980. Heinrich, K. F. J., Yakowitz, H., **Quantitative electron probe microanalysis: fluorescence correction uncertainty,** *Mikrochim. Acta* **5,** 905-916 (1968).

Key words: Electron probe microanalysis; error analysis; fluorescence corrections; quantitative analysis; x-ray fluorescence.

In order to evaluate the fluorescence correction uncertainty in electron probe microanalysis, effects of two general types were investigated. The effects of uncertainty in (1) microprobe operational variables, including x-ray emergence angle and operating voltage, and (2) errors in model input parameters, such as fluorescence yield factors and mass attenuation coefficients, were evaluated. The major conclusion of this study is, that even in cases requiring large fluorescence corrections, microprobe operation at high ($\geqslant 30°$) x-ray emergence angles, and at the lowest voltage compatible with a reasonable x-ray output is entirely satisfactory. This conclusion is reached by substituting into existing fluorescence correction models reasonable input parameter errors, x-ray emergence angles, and operating voltages. Results show that absolute compositional errors vary quite slowly with x-ray emergence angle and operating voltage. The chief source of error among input parameters is the fluorescence yield factor. The role of model selection as a source of potential error is also discussed.

10981. Henderson, M. M., **Introductory remarks and summary of discussion for symposium on critical reviews,** *J. Chem. Doc.* **8,** 231 and 245 (Nov. 1968).

Key words: Authors of reviews; critical reviews; editorial problems; information requirements; publication problems; review journals.

Critical reviews will be examined in terms of the quality and quantity of their present production, and the measure of their value and utility to scientists in meeting information needs. The papers first present the viewpoints of user, sponsor, author, and editor. The speakers and the audience then discussed present problems and possible future solutions to this aspect of information and communication.

10982. Herron, J. T., Penzhorn, R. D., **Mass spectrometric study of the reactions of atomic oxygen with ethylene and formaldehyde,** *J. Phys. Chem.* **73,** No. 1, 191-196 (Jan. 1969).

Key words: Atomic oxygen; ethylene; formaldehyde; kinetics; mass spectrometry; mechanisms; rate constant.

A mass spectrometric study has been made of the reactions of atomic oxygen with ethylene and formaldehyde. The formation of formaldehyde in the ethylene reaction is shown to be independent of the presence of molecular oxygen, and is attributed to a reaction between atomic oxygen and methyl radicals. The formaldehyde reaction has a rate constant at 300 K of 9.0×10^{10} cm^3 mol^{-1} s^{-1}, with an estimated uncertainty of $\pm 3.0 \times 10^{10}$ cm^3 mol^{-1} s^{-1}.

10983. Heydemann, P. L. M., Houck, J. C., **Self-consistent ultrasonic method for the determination of the equation of state of liquids at very high pressures,** *J. Appl. Phys.* **40,** No. 4, 1609-1613 (Mar. 15, 1969).

Key words: Bulk modulus; density; equation of state; high pressure; velocity of sound; water.

Ultrasonic measurements on liquids at very high pressures and an accurate self-consistent ultrasonic method for the determination of the equation of state of liquids at very high pressures are described. The liquid sample is contained in a polyethylene-lined piston and cylinder device. The method described requires only the measurement of the transit time of an ultrasonic pulse through the liquid as a function of pressure. The difficulties and errors connected with a direct volumetric determination are thus avoided and a high accuracy is achieved. A computation of the uncertainties in the determination of the bulk moduli, the density and the velocity of sound is presented. Experimental results are given for water at 22 °C and pressures up to 12.6 kbar. Data for the density of water reported by P. W. Bridgman and by L. H. Adams, and for the velocity of sound reported by Holton, *et al.*, are found to be in good agreement with the present work.

10984. Hicho, G. E., Meyerson, M. R., Geil, G. W., **Effect of slack-quenched structures on the tensile properties of AISI 5140 steel,** (Proc. Intern. Conf. Strength of Metals and Alloys, Tokyo, Japan, Sept. 4-8, 1967), *Suppl. Trans. Japan Inst. Metals* **9,** 134-142 (1968).

Key words: AISI 5140 steel; hardness; heat treatment; reduction of area; slack-quenched structures; tempering temperature; tensile strength; yield strength.

Slack-quenched structures in steels are generally believed to be detrimental even though adequate data on the tensile behavior of these structures are not available. Results are reported of an investigation on the tensile behavior of specimens of AISI 5140 steel slack-quenched to different hardness levels and tested in the conditions as (1) slack quenched and stress relieved at 275 °F, (2) slack quenched and tempered at 400, 550, 700, 850 and 1000 °F, and (3) slack quenched and tempered to selected hardness levels. The tempering of the slack-quenched specimens had a very beneficial effect on the yield behavior and ductility; tempering slack-quenched specimens to a reduction of R_c 5 to 7 in hardness generally produced a maximum increase in the yield strength. Moreover, the yield strength and reduction of area of the slack-quenced specimens tempered to a reduction of R_c 5 to 7 or more in hardness were nearly equal to those of fully-hardened specimens tempered to the same hardness level.

10985. Hiza, M. J., Duncan, A. G., **A simple gas recirculation pump for low flow and high pressure applications,** *Rev. Sci. Instr.* **40,** No. 3, 513-514 (Mar. 1969).

Key words: High pressure; low flow rate; pump; recirculation.

A simple pump is described which was designed to recirculate the gas phase in vapor-liquid phase equilibrium studies at flow rates approximately 100 cc/min and at pressures up to 200 atmospheres.

10986. Hiza, M. J., Heck, C. K., Kidnay, A. J., **Liquid-vapor and solid-vapor equilibrium in the system hydrogen-ethylene,** *Proc. Symp. Cryogenic Advance in the Space Program, Tampa, Florida, May 19-22, 1968,* **64,** No. 88, 57-65 (American Institute of Chemical Engineering, New York, N.Y., 1968).

Key words: Ethylene; hydrogen; hydrogen-ethylene system; liquid-vapor equilibrium; low-temperature phase equilibrium; solid-vapor equilibrium; solubility of hydrogen in liquid ethylene.

Equilibrium gas phase compositions in the system hydrogen-ethylene were measured for nine isotherms from 80 to 170 K generally to 130 atm.; equilibrium liquid phase compositions were measured for four of the isotherms from 122 to 170 K to 150 atm. Gas phase compositions up to 130 K were determined with a single-pass solid-vapor apparatus using continuous analysis with a hydrogen flame-ionization detector. The remainder of the measurements were made in a vapor-recirculating liquid-vapor apparatus using chromatographic analysis with a thermal conductivity detector.

Isobaric comparison of enhancement factors, $y_1\pi/p_{01}$, shows the gas phase data obtained by the two methods to be in excellent agreement. Poor agreement was found with the earlier gas and liquid phase data of Williams and Katz and of Likhter and Tikhonovich. The present investigation provides the only gas phase data below the ethylene triple point, 103.97 K.

10987. Hogben, D., **The distribution of the sample variance from a two-point binomial population,** *Am. Stat.* **32,** No. 5, 30 (Dec. 1968).

Key words: Distribution; parameter; probabilities; random sample; two-point binomial; variance.

In a random sample of size n the sample variance is $S^2 = \Sigma_{i=1}^{n} (\overline{X}_i - \overline{X})^2/(n-1)$. For the two-point binomial distribution, it is shown that for $c = i(n-i)/n(n-1)$ and $i = 0, 1, \ldots, [n/2]$,

$$\Pr\{S^2 = c\} = \binom{n}{i} p^i q^i \ (p^{n-2i} + q^{n-2i}),\ i < n/2, = \binom{n}{n/2} p^{n/2}\ q^{n/2},$$

$$n \text{ even and } i = n/2.$$

Two examples are given.

10988. Hoover, T. B., **The N-methylpropionamide-water system. Densities and dielectric constants at 20-40°,** *J. Phys. Chem.* **73,** No. 1, 57-61 (Jan. 1969).

> Key words: Density; dielectric constant; excess molar volume; Kirkwood correlation parameter; N-methylpropionamide; structure; water.

Densities and dielectric constants of the N-methylpropionamide (NMP)—water system were measured at 20, 30 and 40 °C. The curve of excess molar volume of the system *vs.* mole fraction of water was essentially independent of temperature and had a minimum of -1.32 cm^3 at 0.6 mole fraction of water. The molar volume of transfer of NMP from the pure liquid to a dilute solution in water had a minimum of -6.0 cm^3 at 0.9 mole fraction of water. The dielectric data for the system were analyzed in terms of pseudo-Kirkwood correlation factors, calculated on the basis that the square of the gas-phase moment and the high-frequency dielectric constant for the mixture were linear functions of the mole fractions of the components. The structural properties of the system are discussed with respect to the corresponding data for the mixtures of water with N-methylacetamide, ethanol, or acetic acid. NMP and water each exerts a strong effect on the structure of the other.

10989. Hubbell, J. H., Berger, M. J., **Photon attenuation. Attenuation coefficients, energy absorption coefficients, and related quantities,** Chapter 4 in *Engineering Compendium on Radiation Shielding,* R. G. Jaeger, E. P. Blizard, A. B. Chilton, M. Grotenhuis, A. Honig, T. A. Jaeger, H. Eisenlohr, eds., **1,** 167-202 (International Atomic Energy Agency, Vienna, Austria, 1968).

> Key words: Attenuation coefficient; Compton scattering; cross section; energy absorption coefficient; gamma rays; pair production; photoelectric absorption; photons; x-rays.

This paper consists of two parts. The first part contains tabulations of the photon attenuation coefficient and the energy transfer coefficient. The values of the attenuation coefficient represent a revision which takes into account new theoretical data on the photoelectric effect and on radiative corrections to Compton scattering and pair production. Rayleigh (coherent) scattering and the photonuclear effect are disregarded, but can be included by use of auxiliary tables. The main tables cover the energy range 10 keV to 100 MeV for 21 elements and four mixtures. This range is extended to 10 GeV for 16 elements by interpolation from experimental data. The energy transfer coefficient data were taken directly from tabulations in the literature, and cover the energy range 10 keV to 100 MeV. In the second part, information is given on the individual processes (photoelectric absorption, Compton scattering, pair production and other interactions of photons with matter) which combine to give the attenuation coefficient. Theoretical and experimental data are reviewed, and numerical tables and approximation formulas are given.

10990. Hudson, R. P., **The delta campaign. An account of the controversy surrounding the temperature scale for CMN,** *Cryogenics* **9,** No. 2, 76-79 (Apr. 1969).

> Key words: CMN; low temperature; paramagnetic susceptibility; thermometry.

Theory predicts that the susceptibility of cerous magnesium nitrate will closely approximate Curie's law below 1 K and into the millikelvin region. Specifically, $\chi = c(T - \theta)^{-1}$, with $\theta = -0.27$ mK. Single crystal specimens substantiate this prediction down to about 6 mK, below which strong deviations begin to appear and the susceptibility reaches a limiting, maximum value for temperatures below 2 mK. On the other hand, thermometers fashioned (for convenience) from powdered CMN and shaped into cylinders of diameter equal to height, appear—from the properties of ^{3}He and expectations as to their temperature-dependence—to obey Curie's law down to 3 mK and below. Such drastic differences are of considerable importance, inasmuch as CMN is the only practical thermometer currently available for this region of temperature.

At various times, interested parties have expressed strong views that either the single crystal thermometric results or those for powder cylinders were wrong, or speculated that both might be correct. A condensed survey is here presented of the details of the dilemma, recent attempts to resolve it, and the situation at present.

10991. Hudson, R. P., Kaeser, R. S., **Magnetic temperature scale 0.002–5 K,** *Proc. Xth Intern. Conf. Low Temperature Physics, Moscow, U.S.S.R., Aug. 31-Sept. 6, 1966,* **Vol. 1,** *Properties of Helium,* Paper H4, pp. 171-173 (1968).

> Key words: Cerous magnesium nitrate; low temperatures; magnetic cooling; magnetic thermometer; paramagnetic salt; temperature scale.

Our previous measurements of the heat capacity of cerous magnesium nitrate (CMN) as a function of susceptibility using gamma-ray heating have been superseded by new data obtained with a new single-crystal sphere following various improvements in apparatus and procedure. The entropy-susceptibility relation is the same for all specimens and is thus independent of ellipsoid axial ratio; the indicated value of b (coefficient of T^{-2} for "high temperature" heat capacity) is 15 percent smaller than calculated by Cooke, Duffus and Wolf. Combining the heat capacity and entropy data led to values of absolute temperature, which fall below 0.002 K for the lowest entropy obtained, viz. $S/R = 0.25$. In the region between 0.02 and 0.2 K where both dipole-dipole and lattice specific heat are very small, an anomalous and apparently nonmagnetic contribution to the heat capacity was detected. No explanation for this has been found, but its existence undoubtedly accounts for the apparently non-isentropic demagnetizations experienced for "starting conditions" H/T less than 0.37 oersteds deg^{-1}.

10992. Huget, E. F., Brauer, G. M., **Reactivity of the components of tooth structure,** *J. Colloid Interface Sci.* **27,** No. 4, 714-721 (Aug. 1968).

> Key words: Anorganic whole tooth; components of tooth; dentin; heat of reaction; reactivity of anorganic whole tooth surfaces; reactivity of dentin surfaces.

A restorative material capable of adhering to tooth structure is greatly needed. Bonding is complicated by the complex nature of tooth structure as well as the mechanical, toxicologic and bacteriologic conditions which occur in the oral cavity. Heats of immersion ($-\Delta H_w$) measurements for dentin, enamel and anorganic whole tooth tissue of known specific surface have been used to study the reactivity and degree of surface modification produced by various ions and functional groups in an aqueous environment. A decrease in the $-\Delta H_w$ value of dentin in water from 10.3 cal/g (4100 ergs/cm^2) to 4.0 cal/g (1590 ergs/cm^2) in 2-40 percent aqueous solutions of organic solvents suggests the strengthening of electrostatic bonds between polar groups of the collagenous matrix of dentin. In absolute ethanol and hexane, dentin absorbs heat indicating the weakening of hydrophobic bonds. $-\Delta H_w$ values for anorganic whole tooth in aqueous solutions of organic solvents are not appreciably different from those obtained in water (109 ergs/cm^2). The presence of NO^-_3, NO^-_2, CNS^-, $_2SO^-_4$, and I^-, at pH 5 depressed the $-\Delta H_w$ of dentin to 4.8 cal/g (1910 ergs/cm^2). Other anions (F^- and Cl^-) had no appreciable effect. At pH 8, however, anions did not appreciably alter the $-\Delta H_w$ of dentin. The addition of aldehyde groups to the liquid adsorbate at pH 8 resulted in the lowering of the apparent $-\Delta H_w$ value of dentin. Changes in $-\Delta H_w$ values for anorganic whole tooth in the presence of anions or aldehyde groups were relatively small.

10993. Hummer, D. G., **Non-coherent scattering-IV. Doppler redistribution functions in moving atmospheres,** *Monthly Notices Roy. Astron. Soc.* **141,** 479-488 (Dec. 1968).

Key words: Non-coherent scattering; radiation transfer; redistribution function; spectral line.

Redistribution functions and their directional averages are derived for scattering by an assembly of atoms possessing a Maxwellian distribution in a frame moving with respect to the observer. Various assumptions concerning the form of the absorption coefficient and the coherence properties in the atom's rest frame are considered. The exact redistribution function for pure Doppler broadening is expanded in Legendre polynomials to facilitate evaluation of the source function. From the expansion it is clear that the use of direction-averaged redistribution functions will be significantly less accurate for moving than for static media.

10994. Hummer, D. G., Rybicki, G. B., **Line formation in differentially moving media with temperature gradients,** *Proc. Natl. Center for Atmospheric Research Conf. Resonance Lines in Astrophysics, Sept. 9-12, 1968, Boulder, Colo.*, pp. 315-330 (National Center for Atmospheric Research, Boulder, Colo., Dec. 1968).

Key words: Planetary nebulae; radiative transfer; spectral lines; velocity fields.

The line formation problem for two-level atoms scattering with complete redistribution is solved numerically for plane parallel media in which the macroscopic velocity, electron temperature and all other properties of the atmosphere are arbitrary functions of optical depth.

10995. Hummer, D. G., Rybicki, G. B., **Red-shifted line profiles from differentially expanding atmospheres,** *Astrophys. J.* **153,** No. 2, L107-L110 (Aug. 1968).

Key words: Expanding atmosphere; red-shift; spectral line.

Solutions of non-LTE line transfer methods for a differentially expanding atmosphere are shown to possess a red-shifted intensity peak in cases when a substantial fraction of the atmosphere is moving towards the observer. This phenomenon arises because photons in the red wing of the line see a smaller opacity than do those in the blue wing and therefore escape more readily.

10996. Hutchinson, J. M. R., Mann, W. B., Smith, C. N., Whittaker, J. K., **The half lives of two excited states in ^{239}Np,** *Intern. J. Appl. Radiation Isotopes* **20,** No. 7, 493-498 (July 1969).

Key words: Alpha-particle; americium-243; excited states; gamma-ray; half-life; neptunium-239.

The half-life of the 74 keV(5/2-) state of ^{239}Np has been determined to be 1.380 ns ± 0.032 ns where the uncertainty represents the sum of estimated bounds to the systematic error, ±0.010 ns, and twice the standard error of the mean, ±0.022 ns. The half-life of the 118 keV(7/2-) states of ^{239}Np has been found to be less than 0.04 ns.

10997. Hyde, K. E., Gordon, G., Kokoszka, G. F., **Magnetic properties of some binuclear copper(II) complexes,** *J. Inorg. Nucl. Chem.* **30,** 2155-2161 (1968).

Key words: Copper monochloroacetate 2.5 hydrate; dichlorobis-(pyridine-N-oxide)copper(II); dichloromonoaquo-(pyridine-N-oxide)copper(II); exchange interactions; J values; magnetic susceptibility; spin-spin coupling.

The magnetic susceptibility of three binuclear copper compounds, dichloromonoaquo-(pyridine-N-oxide)copper(II), [$CuCl_2$(pno)], dichlorobis(pyridine - N - oxide)copper(II), [$CuCl_2$(pno)$_2$, and copper monochloroacetate 2.5 hydrate, [Cu(ClAc)$_2$], has been measured as a function of temperature. The exchange integral, J, has been determined to be 943 cm^{-1}, 770 cm^{-1}, and 292 cm^{-1} for $CuCl_2$(pno), $CuCl_2$(pno)$_2$, and Cu(ClAc)$_2$, respectively. These values are compared to the J values determined by electron spin resonance on the same three compounds. A brief discussion of the accuracy of these values is presented. In addition, for two of the compounds, Cu(ClAc)$_2$ and Cu(pno), a better fit of the data was possible by assuming the presence of a small amount of monomeric ion in the samples. This was verified by additional ESR measurements.

10998. Ito, J., Johnson, H., **Synthesis and study of yttrialite,** *Am. Mineralogist* **53,** 1940-1952 (Nov. 1968).

Key words: Crystal chemistry; gel-preparation; inorganic synthesis; mineral identification; polymorphism; rare-earth silicate; solid solubility; x-ray powder analysis.

The rare-earth pyrosilicates, $R_2^3\ Si_2O_7(R^3 = Sc$, In, Lu, Yb, Tm, Er, Ho, Y, Dy, and Gd) were synthesized at temperatures from 900-1,600 °C in air. "High-yttrialite" was identified as α-(Y,RE)$_2Si_2O_7$ from the results of recrystallization of the natural mineral and by direct synthesis from gels both in air and under water pressure.

A solid solution series exists between $Sc_2Si_2O_7$(thortveitite) and ρ-$Y_2Si_2O_7$ at 1,300 °C in air and at 700 °C under 2.5 kb. The compositional range from $Y_2SiO_5 - Y_2Si_2O_7 - Y_2Si_3O_9$ was investigated at temperatures from 900-1,500 °C.

The phase described as "low-yttrialite" is a complex silicate of approximate formula R(Y,RE)$_5Si_6O_2$ where R includes ions of great variety, such as Na, Mg^2, Fe^2, Fe^3, Al^3, Mn^2, Th^4 and Zr^4.

10999. Iverson, W. P., **Mechanisms of microbial corrosion,** (Proc. First Intern. Biodeterioration Symp., Southhampton, England, Sept. 9-14, 1968), Chapter in *Biodeterioration of Materials. Microbiological and Allied Aspects*, pp. 28-43 (Elsevier Publ. Co., Ltd., Essex, England, 1968).

Key words: Anaerobic corrosion; cathodic depolarization; corrosion mechanisms; metabolic products; microbial corrosion; oxygen concentration cells.

A discussion of the general and specific mechanisms of microbial corrosion with special emphasis on anaerobic corrosion. General mechanisms include the production of corrosive metabolic products, the initiation of oxygen concentration cells and cathodic depolarization. Recent evidence to be presented indicates that the cathodic depolarization theory may at least in part explain the corrosion due to microorganisms in an anaerobic environment.

11000. Iverson, W. P., **Microbiological corrosion,** *Proc. Conf. Corrosion and Protection of Pipes and Pipelines, London, England, June 13, 1968*, 6 pages (Technical Exhibited Ltd., London, England, 1968).

Key words: Anaerobic corrosion; cathodic depolarization; desulfovibrio; microbial corrosion; sulfate-reducing bacteria; thiobacilli; underground pipeline corrosion.

A discussion of the microorganisms associated with microbial corrosion with emphasis on the sulfate reducers. The mechanisms by which these microorganisms can cause corrosion include: (a) the production of corrosive metabolic products; (b) the formation of concentration cells; (c) cathodic depolarization; (d) combinations of (a), (b) and (c); (e) miscellaneous mechanisms. Corrosive metabolic products which are formed include hydrogen sulfide, ammonia and various acids. The formation of concentration cells will be discussed as it relates to the exterior and interior of pipelines. As the mechanism of cathodic depolarization by bacterial action has been so generally postulated to explain anaerobic corrosion of buried structures, recent evidence for and against this mechanism will be elaborated upon. Practical measures to be instituted in preventing microbial corrosion involve placing underground structures, whenever possible, in "non-aggressive" soil or protection of structures in "aggressive" soil by cathodic protection, protective coatings, or both.

11001. Ives, J. M., Hughes, E. E., Taylor, J. K., **Absolute determination of low concentrations of oxygen in inert gases by means of galvanic cells,** *Anal. Chem.* **40,** No. 12, 1853-1856 (Oct. 1968).

> Key words: Galvanic cells; gas analysis; gas analysis using electrochemical methods; oxygen determination; trace gas analysis; trace oxygen determination.

A method has been developed for the absolute determination of oxygen in inert gases over the range from about 1 to 1000 ppm oxygen. The gas to be analyzed is caused to flow through a series of galvanic cells similar to the type developed by Hersch. Under the conditions used, most of the oxygen in a stream of gas is removed in the first cell; subsequent cells reduce oxygen concentrations to virtually zero in the effluent gas. Measurement of the increase in all cell current outputs when the gas flow rate is increased by a known increment allows calculation of the absolute oxygen concentration.

11002. Jacox, M. E., Milligan, D. E., **Matrix-isolation study of the infrared spectrum of the free radical F_2CN,** *J. Chem. Phys.* **48,** No. 9, 4040-4046 (May 1, 1968).

> Key words: CF_2NF; CF_3NF_2; F atom reaction; FCN; F_2CN; FC=NF; free radical; infrared spectrum; matrix isolation; photolysis; ultraviolet spectrum.

In studies of the reaction of photolytically produced F atoms with FCN in Ar and N_2 matrices at 14 K, the free radical F_2CN is stabilized in sufficient concentration for observation of its electronic spectrum and of six infrared absorptions. A vibrational assignment has been made. The carbon-nitrogen bond is found to possess double bond character. Products of further F atom attack on F_2CN, including CF_2NF and CF_3NF_2, are observed in these experiments. Evidence is presented suggesting that the species FC=NF may also be stabilized.

11003. Jacox, M. E., Milligan, D. E., **Matrix-isolation study of the vacuum-ultraviolet photolysis of trichlorosilane. The infrared spectrum of the free radical $SiCl_3$,** *J. Chem. Phys.* **49,** No. 7, 3130-3135 (Oct. 1, 1968).

> Key words: Force constants; free radical; infrared spectrum; matrix isolation; photolysis; $SiCl_3$; trichlorosilane; ultraviolet spectrum.

In studies of the vacuum-ultraviolet photolysis of $HSiCl_3$ in argon and nitrogen matrices at 14 K, features appear near 470 and 582 cm^{-1} which may be identified with the two stretching fundamentals of $SiCl_3$. Evidence supporting primary photodecomposition by detachment of the H atom has been obtained in CO matrix experiments, in which HCO is a major product. The observed frequencies permit estimation of an angle of $72 \pm 5°$ between the threefold axis and each of the Si-Cl bonds. Force constants have also been estimated. The FG-matrix treatment is presented for the stretching modes of a nonplanar X_2YZ species with equal XYX and XYZ valence angles. The calculated frequency and intensity pattern for the mixed chlorine isotopic species is in excellent correspondence with the observed pattern, providing strong support for the identification and proposed vibrational assignment. Unstructured absorptions between 2900 and 3300 Å and between 2150 and 2450 Å are tentatively attributed to $SiCl_3$.

11004. Jespersen, J. L., Kamas, G., Gatterer, L. E., MacDoran, P. F., **Satellite VHF transponder time synchronization,** *Proc. IEEE* **56,** No. 7, 1202-1206 (July 1968).

> Key words: Atomic oscillators; clock synchronization; VHF satellite transponder.

This paper describes an experiment designed to transfer accurate time between two widely separated clocks using a VHF satellite transponder. The satellite used was the NASA Application Technology Satellite ATS-1. The experiment used atomic oscillators to maintain accurate time at each station and the synchronization was accomplished by measuring the round trip delay times between the stations. The goal of the experiment was to evaluate a VHF system because of the low cost ground equipment involved. This was in contrast to microwave systems. The paper discusses the results and the various factors that contributed to the timing errors.

11005. Johannesen, R. B., Gordon, C. L., **Titanium(IV) bromide (titanium tetrabromide),** Chapter IV in *Inorganic Syntheses* **IX,** 46-50 (McGraw-Hill Book Co. Inc., New York, N.Y., 1967).

> Key words: Hydrogen bromide; titanium; titanium tetrabromide; titanium tetrachloride.

Directions are given for the preparation of titanium tetrabromide. Distilled titanium tetrachloride is treated with an excess of gaseous hydrogen bromide and the product distilled under dry nitrogen into a container which can be sealed. Titanium tetrabromide prepared in this manner was found to contain 0.03 percent of chloride. The yield was 85 percent.

11006. Johnson, V. J., **Development and operation of a specialized technical information and data center (The Cryogenic Data Center),** *J. Chem. Doc.* **8,** No. 4, 219-224 (Nov. 1968).

> Key words: Bibliography service; cryogenics; current awareness; data center; data evaluation; development; information retrieval; operation; technical information center.

As is typical of many specialized areas of science and technology, cryogenics has had an explosive development in the last decade and a half. The Cryogenic Data Center was established in 1958 to cope with the problem of organizing the world's literature pertinent to the field of cryogenics and furnishing this rapidly developing industry with reliable information and data. The development of this facility over the ten year period of its existence is discussed. Included is a description of the conversion from a manual to an automated bibliographic retrieval system, the development of cataloging and indexing techniques, the development of comprehensive awareness and literature acquisition procedures with public announcement of new literature, procedures for selecting and compiling data, and finally how the needs of the sponsors and the industry are being served. The discussion emphasizes the problems that are typical in facilities of this type and the need to consider standard or generally accepted solutions. The growing trend for a network system of technical information and data centers requires a high order of compatibility among them.

11007. Joiner, B. L., Rosenblatt, J. R., **The mean deviation and range for $n = 3$,** *Am. Stat.* **22,** No. 4, 37-38 (Oct. 1968).

> Key words: Mean deviation; range; samples of size 3; statistics.

Although it is well known that the mean deviation from the sample median is identical to one-third the range for samples of size three from *any* distribution, it is not so well known that the mean deviation from the sample mean has the same distribution as $2/\sqrt{27}$ times the range for samples of size three from the *normal* distribution. In this note a simple method of proving the relationship between the distributions is given, based on the fact that linear functions of normal random variables are normally distributed.

11008. Jones, M. C., Giarratano, P. H., Simpson, A. U., **Flow and heat transfer characteristics of sub-triple-point cryogens in heated tubes,** *Proc. Second Intern. Cryogenic Enineering Conf., Brighton, England, May 7-10, 1968,* pp. 83-88 (Iliffe Science and Technology Publ., Ltd., Guilford, Surrey, England, 1968).

Key words: Flow; hydrogen; nitrogen; solid plug; solid-vapor mixture; sub-triple point; tubes.

When liquids are expanded to pressures below their triple point pressures they form two-phase, solid-vapor mixtures. The continuous discharge of such mixtures through tubes is important in a variety of situations in space vehicles, but this can only be assured if the tubes are heated. By studying heat transfer some insight has been gained into the mechanism of particle-wall interaction, which leads eventually, at low heat input, to a tube completely plugged with solid. A similarity criterion is proposed by which minimum adequate heating conditions might be correlated. Experimental values are given.

11009. Judd, D. B., **1964 CIE supplementary observer applied to the colorimetry of rutile and anatase forms of titanium dioxide,** *J. Opt. Soc. Am.* **58,** No. 12, 1638-1649 (Dec. 1968).

Key words: Color difference; colorimetry; color-matching functions; titanium dioxide; whiteness.

The study by White and Jacobsen of the applicability of the 1964 CIE supplementary observer to large-field colorimetry of the rutile and anatase crystal forms of titanium dioxide has been repeated. The six painted panels used by them were remeasured on a Hardy-type spectrophotometer with closely agreeing results. The arrangement of the panels in order of whiteness by north-sky light was made by 24 observers, yielding 45 arrangements, and these too were in good inverse agreement with the 26 yellowness arrangements made by 13 observers by White and Jacobsen. The spectrophotometric data were reduced to values of U^*, V^*, W^* of the 1964 CIE uniform color space, and the sizes of the chromaticity differences between each panel and the magnesium oxide whiteness standard were computed. By substituting, for CIE illuminant C, the newly recommended CIE illuminants D_{6500} and D_{25000}, representative of overcast sky and clear sky, respectively, and by taking account of normal variations of amount of lens pigment from one observer to another, we found that the 1964 CIE supplementary observer yields correct predictions of the frequency of the various whiteness arrangements of the six panels.

11010. Judd, D. B., **Color science and the paint industry,** *J. Paint Technol.* **40,** No. 525, 470-477 (Oct. 1968).

Key words: Absorption; color; colorant; metamerism; paint; scattering; spectrophotometry.

The principal color problems of the paint industry are color control, color permanence, colorant formulation, and filing of paint information according to color. To assist in solving these problems, color science has to offer, first and foremost, the spectrophotometer; second, the weighting functions defining the 1931 CIE standard observer for colorimetry; third, various tridimensional systems of color notation; and finally, the Kubelka-Munk theory of the light reflected by a layer which both absorbs and back-scatters the incident light. The spectrophotometer assists in color control by providing a permanent record of the reflectance of the paint chip as originally prepared. It also provides the basic data by means of which colorant formulation by instruments is possible. Tridimensional systems of color notation provide convenient forms for filing of paint recipes and production notes. The Kubelka-Munk theory provides the basic structure by which colorant formulation by instrumentation becomes routinely practical for large organizations.

11011. Kahn, A. H., **Polarons in anisotropic energy bands,** *Phys. Rev.* **172,** No. 3, 813-815 (Aug. 15, 1968).

Key words: Effective mass; energy bands; ionic crystals; polarons; semiconductors; strontium titanate.

The polaron weak coupling approximation has been applied to the problem of an electron on a spheroidal energy surface interacting with longitudinal optical phonons. The binding energy and effective masses are calculated. For $SrTiO_3$, where the observed masses are $m_l^*/m_o = 6.0$ and $m_t^*/m_o = 1.5$, the calculated bare masses are 4.7 and 0.96, respectively, and the binding energy is 0.26 eV. It is also shown how the polaron properties may be calculated when the band edge is of the degenerate type.

11012. Kamper, R. A., **Cryoelectronics,** *Cryogenics* **9,** No. 1, 20-25 (Feb. 1969).

Key words: Electronics; low temperature; superconducting devices.

This is a review of the progress to date in applying superconductivity to electronics.

11013. Kaufman, V., Radziemski, L. J., **Redetermined level values and interaction parameters of S I and Cl II ground configurations,** *J. Opt. Soc. Am.* **59,** No. 2, 227-228 (Feb. 1969).

Key words: Chlorine; energy levels; ground configurations; Slater-parameters; sulfur; vacuum-ultraviolet.

Values for the levels of the ground configurations of S I and Cl II have been determined from new wavelength measurements in the vuv spectral region. Calculations of the Slater parameters to fit these levels were made and indicate the need for the configuration interaction parameter, α.

11014. Keller, R. A., **Excited triplet → singlet intersystem crossing,** *Chem. Phys. Letters* **3,** No. 1, 27-29 (Jan. 1969).

Key words: Delayed fluorescence; fluorescence; intersystem crossing; phosphorescence; triplet states.

The quantum yield for intersystem crossing from excited triplet states into the singlet manifold was estimated for several molecules by observing the fluorescence emission from the lowest excited singlet state which resulted from photo-excitation of metastable triplet states. In all cases these quantum yields were very small.

11015. Keller, R. A., Dolby, L. J., **Intramolecular energy transfer between triplet states of weakly interacting chromophores. III. Compounds in which the chromophores are separated by a rigid steroid bridge,** *J. Am. Chem. Soc.* **91,** No. 6, 1293-1299 (Sept. 1969).

Key words: Energy transfer; fluorescence; phosphorescence; triplet state.

The intramolecular transfer of triplet excitation between chromophores held approximately 15A apart by a rigid steroid bridge was measured for two molecules. The acceptor in both cases is the naphthalene chromophore. In I the donor is the benzophenone chromophor and in II the donor is the carbazole chromophore. The rate constant for transfer is 25 s^{-1} for I and 0.04 s^{-1} for II. The 1000 fold difference in these rate constants is paralleled by the 1000 fold difference in the triplet state lifetime for two donor chromophores. In both cases the transfer of singlet excitation energy was more than the transfer of triplet excitation energy.

11016. Kelley, R. D., Klein, R., Scheer, M. D., **The *cis-trans* effect in the H-atom addition to olefins,** *J. Phys. Chem.* **73,** No. 4, 1169-1170 (Apr. 1969).

Key words: Addition reactions; *cis, trans*; hydrogen atom; octadiene.

The relative rate of addition of hydrogen atoms to the two π-bonds in *cis, trans* 2,6-octadiene has been measured in the cryogenic temperature region. It has been found that the addition reaction at the *trans* double bond is 20 percent faster than at the *cis* double bond. This effect is independent of temperature in the region 90 to 143 K. Similar results by other workers for other *cis-trans* systems suggest that this effect be ascribed to steric hindrance of the approach of the hydrogen atom.

11017. Kim, Y-K., Inokuti, M., Chamberlain, G. E., Mielczarek, S. R., **Minima of generalized oscillator strengths,** *Phys. Rev. Letters* **21,** No. 16, 1146-1148 (Oct. 14, 1968).

Key words: Absolute; cross section; electron; generalized oscillator strengths; theory; xenon.

Frequent occurrence of zero or near-zero minima of the generalized oscillator strength is closely connected with the nodes of the radial wave functions for the states involved. Some general implications of the minima are discussed, and, as an example, experimental and theoretical results for a transition in Xe are presented.

11018. King, R. J., Maley, S. W., Wait, J. R., **Experimental and theoretical studies of propagation of ground waves across mixed paths,** (Proc. URSI Symp. Electromagnetic Wave Theory, Delft, Holland, Sept. 1965), Chapter in *Electromagnetic Wave Theory,* J. Brown, ed., pp. 217-224 (Pergamon Press Inc., New York, N.Y., 1965).

Key words: Electromagnetic ground waves; ground waves; nonhomogeneous paths; propagation of ground waves.

The propagation of electromagnetic ground waves along nonhomogeneous paths has received considerable interest in the past three decades. As a result, several empirical and semi-empirical solutions have been developed and proven useful in calculating the portion of a ground wave transmitted across a coast line. These methods generally have been replaced by more rigorous formulations. Experimental results have been rather meager since ground waves are primarily important at low and very low frequencies where the distances involved are large. Furthermore, it is difficult to evaluate the unwanted effects of other nearby terrain and objects. Therefore, the experiments described here have utilized small laboratory models which simulate, as closely as possible, the mathematical model used in the theoretical formulations. In this way, distances and other parameters can be carefully measured and controlled. If the experimental results compare favorably with the theoretical solution, the theory can then be applied to naturally occurring mixed paths with considerably more confidence.

11019. Kirby, R. K., Rothrock, B. D., **Thermal expansion of vitreous selenium from −190 to +30 °C,** *J. Am. Ceram. Soc.* **51,** No. 9, 535 (Sept. 1968).

Key words: Grüneisen's parameter; linear thermal expansion; vitreous-selenium.

A vitreous-silica dilatometer was used to measure the linear thermal expansion of selenium glass from −190 to +30 °C. An attempt to measure the expansion above 30 °C with an optical comparator did not produce satisfactory results. The coefficients of linear thermal expansion at −190, 0, 20, and 30 °C are 32.4, 45.5, 51.3 and 93×10^{-6} °C respectively. Grüneisen's parameter was determined to be constant, $\gamma = 1.0 \pm 0.1$, over the temperature range −190 to +20 °C.

11020. Kirchhoff, W. H., **The microwave spectrum, structure, and dipole moment of *cis*-thionylimide,** *J. Am. Chem. Soc.* **91,** 2437-2442 (1969).

Key words: Dipole moment; HNSO; isotopic species; microwave spectrum; Stark effect; structural parameters.

The microwave spectrum of thionylimide, HNSO, has been observed and assigned to the planar, *cis* form. The structural parameters are $d_{NH} = 1.029 \pm 0.01$ Å, $d_{NS} = 1.512 \pm 0.005$ Å, $d_{SO} = 1.451 \pm 0.005$ Å, $<\text{HNS} = 115.8° \pm 1°$ and $<\text{NSO} = 120.4° \pm 0.5°$ where the uncertainties are estimated to account for the effects of zero point vibrations. The dipole moment and its components along the principal axes in the $HN^{15}SO$ isotopic species are $\mu_a = 0.893 \pm 0.003$ Debyes, $\mu_b = 0.181 \pm 0.005$ Debyes and $\mu = 0.911 \pm 0.003$ Debyes where the uncertainties are the standard deviations of the reported values, from the least squares analysis. Since no attempts were made to make a complete assignment of the impure sample, no comments can be made about the possible existence of *trans*-NSO.

11021. Klein, M., Hanley, H. J. M., **Selection of the intermolecular potential. Part 2. From data of state and transport properties taken in pairs,** *Trans. Faraday Soc.* **64,** Part 2, No. 551, 2927-2938 (Nov. 1968).

Key words: Equilibrium properties; experimental data; intermolecular potential function; simultaneous correlation; theory; transport properties.

In a previous paper we developed a method to evaluate quantitatively the relationship between intermolecular potential functions and macroscopic properties. This method was applied to a study of the second virial, Joule-Thomson, viscosity and diffusion coefficients. In this work the method has been extended to the simultaneous fit of all possible pair combinations of these properties. As before the relationship between function families available at this time has been clarified. New results from this investigation give important information on the possible simultaneous fit of a simple function to more than one property. The function families studied were the m-6, Kihara, exp-6 and Morse functions.

11022. Klose, J. Z., **Atomic lifetime measurements with pulsed electron beams,** (Proc. Beam-Foil Spectroscopy Conf., Univ. of Arizona, Tucson, Arizona, Nov. 20-22, 1967), Chapter in *Beam-Foil Spectroscopy* **II,** 285-304 (Gordon and Breach Science Publ. Inc., New York, N.Y., 1968).

Key words: Argon; atomic lifetimes; atomic spectra; helium; laser; neon.

Following a short discussion of the general method of measuring atomic lifetimes using pulsed electron beams, four separate determinations of the mean lives of the ten 2p levels (Paschen notation) in Ne I are presented for comparison. These four sets of results from different experimental groups are found to be in general agreement. Mention is next made of the published lifetime measurements in Ar I (2p levels) and Ar II without presentation of results. Finally, measurements of the pressure-dependent lifetime of the $3s_2$ laser level in Ne I are analyzed using the Holstein theory of the imprisonment of resonance radiation. The analysis yields information about transition probabilities from which are derived the $3s_2$ lifetimes for absence of imprisonment (28 ± 5 nsec) and complete imprisonment (52 ± 2 nsec) of the 600.04 Å ($3s_2 \rightarrow {}^1S_0$) resonance radiation.

11011A. Klose, J. Z., **Experimental lifetimes of the 5p levels in argon I,** *J. Opt. Soc. Am.* **58,** No. 11, 1509-1512 (Nov. 1968).

Key words: Argon; atomic lifetimes; atomic spectra.

Mean lives of seven of the ten 5p atomic levels in Ar I have been determined using electronic excitation and a method of delayed coincidence. The measured values and standard deviations in ns of the mean lives of the $3p_1$ and $3p_5$ through $3p_{10}$ (Paschen notation) levels in neutral argon are as follows: $3p_1$, 80 ± 1; $3p_5$, 96 ± 2; $3p_6$, 124 ± 3; $3p_7$, 136 ± 2; $3p_8$, 180 ± 5; $3p_9$, 141 ± 2; and $3p_{10}$, 189 ± 3. Wavelengths used in the determinations ranged from 4159 to 4702 Å. The lifetimes were estimated to contain systematic errors varying from 5 to 15 percent and are presented in comparison with values obtained by combining theoretical calculations with other experimental results.

11023. Koidan, W., **Calibration of standard condenser microphones: coupler versus electrostatic actuator,** *J. Acoust. Soc. Am.* 4, No. 5, 1451-1453 (Nov. 1968).

Key words: Calibration of microphones; microphone calibration standards.

The response-frequency characteristic of a "one-inch" condenser microphone measured by an electrostatic actuator is likely to be significantly different from that measured by reciprocity in an acoustic coupler because of the radiation impedance of the microphone diaphragm with the actuator in place. It cannot be assumed, except at low frequencies, that the radiation impedance is negligible and that the actuator calibration yields the pressure response. Such an assumption also is apt to lead to errors in the determination of the free-field response when calculated with the aid of the free-field correction.

11024. Kokoszka, G. F., Linzer, M., Gordon, G., **Electron paramagnetic resonance spectra of polycrystalline dimeric complexes. Copper propionate monohydrate and zinc-doped copper propionate monohydrate,** *Inorg. Chem.* **7,** No. 9, 1730-1735 (Sept. 1968).

Key words: Copper propionate monohydrate; dimeric complexes; e.p.r.; exchange coupled; polycrystalline samples.

The electron paramagnetic resonance spectra have been observed in the polycrystalline form of copper propionate monohydrate and zinc-doped copper propionate monohydrate. The studies were carried out at liquid nitrogen temperature and at both X-band and K-band frequencies. The K-band $S=1$ spectrum arises from $\Delta m=1$ and $\Delta m=2$ transitions. Copper nuclear-hyperfine structure was observed in the parallel spectra at X-band and K-band frequencies as well as in the $\Delta m=2$ spectral region at K-band. The magnetic parameters for the exchange-coupled copper-copper pairs are $g_{\|}=2.348$, $g_{\perp}=2.060$, $A_{\|}=0.0073$ cm^{-1}, $A_{\perp}<0.001$ cm^{-1}, $D=0.327$ cm^{-1}, and $E<0.001$ cm^{-1}. For the $S=1/2$ spectra associated with the copper-zinc pairs, the magnetic parameters are $g_{\|}=2.348$, $g_{\perp}=2.064$, $A_{\|}=0.0152$ cm^{-1}, and $A_{\perp}=<0.001$ cm^{-1}. A consistent interpretation of the data is presented on the basis of a weak metal-metal interaction. A simple model is used to estimate covalency parameters for the metal-ligand bonds. Upper limits for the exchange integrals and the supertransferred hyperfine interaction are also derived from the data.

11025. Koonce, C. S., Cohen, M. L., **Theory of superconducting semiconductors and semimetals,** *Phys. Rev.* **177,** No. 2, 707-719 (Jan. 10, 1969).

Key words: Dielectric function; Green's function; semiconductors; semimetals; superconductivity.

A Green's function method is used to derive a superconducting energy gap equation without the assumption that the Fermi energy is much larger than phonon energies. This equation is then approximated using two separate methods. The first method applies when the screened electron-phonon interaction is almost independent of wavevector and the Fermi energy is of the order of, or larger than phonon energies. The gap equation obtained in this way takes account of the variation in the density of electron states with energy. The second approximation method applies when the screened electron-phonon interaction depends strongly on wavelength or when the Fermi energy is small compared to phonon energies. In this case, the gap equation takes account of the wavevector dependence of the interaction, the wavevector and frequency dependence of the electronic screening, the energy dependence of the density of states, and the wavevector dependence of the superconducting energy gap. In addition, the effects of the retardation of the electron-electron interaction are also included.

11026. Kraft, R., **An unusual mixed initial boundary problem in two independent variables,** *J. Math. Anal. Appl.* **25,** No. 2, 233-249 (Feb. 1969).

Key words: Hyperbolic system; mixed initial boundary; outgoing data; partial differential equations.

Consider for the hyperbolic system with constant coefficients (1) $(\alpha_i\cdot\nabla)\ U^i-\Sigma_{j=1}^{4}A_{ij}U^j\equiv(\alpha_{i1}\ \partial_x+\alpha_{i2}\ \partial_y)U^i-\Sigma_{j=1}^{4}A_{ij}U^j=0$, $i=1,\ldots 4$ where $A_{ii}=0$, $i=1,\ldots 4$ and the unit vectors $\alpha_i\equiv(\alpha_{i1},\alpha_{i2})$ satisfy $\alpha_{11}>\alpha_{21}>0>\alpha_{31}>\alpha_{41}$; $\alpha_{i2}>0$ the initial boundary problem in the first quadrant with $U\equiv(U^1,\ldots U^4)\epsilon C^2$ given on the positive x-axis and *outgoing* data U^3, $U^4\epsilon C^2$ given on the positive y-axis. Theorem: If $A_{31}A_{42}/\cdot\alpha_1 N_3)(\alpha_2\cdot N_4)-A_{22}A_{41}/(\alpha_2\cdot N_3)(\alpha_1\cdot N_4)\neq 0$ where $N_j\equiv(\alpha_{j21}-\alpha_{j1})$ and certain consistency conditions at the origin are satisfied, then a solution of (1) of class C^1 exists in the first quadrant. Using Riemann functions the incoming data is calculated on the y-axis and this is used to find the solution by the standard method of successive approximations.

11027. Krause, R. F., Jr., Douglas, T. B., **The heats of formation of $AlClF_2$ and $AlCl_2F$ from subliming AlF_3 in the presence of $AlCl_3$ vapor,** *J. Phys. Chem.* **72,** No. 10, 3444-3451 (Oct. 1968).

Key words: $AlCl_3$; AlF_3; dimerization correction; entrainment method; heat of reaction; mixed halides; sublimation.

The volatility of AlF_3, which was measured between 1196 and 1256 K by an entrainment method, was enhanced by the presence of $AlCl_3$ vapor. When the $AlCl_3$ vapor was generated at 373 or 394 K, the amount of sublimed AlF_3 was observed to be from 1.7 to 7.4 times that expected in an inert medium. The vapor mixture saturated with AlF_3 was considered to include the two mixed-halide monomers formed according to:

$$(m/3)AlCl_3+(1\text{-}3/m)AlF_3=AlCl_mF_{(3-m)},$$

where m is 1 or 2. After correcting for the formation of Al_2F_6, Al_2Cl_6, and the 22 possible mixed-halide dimers, a least-square fit to the entrainment data yielded $\Delta H^\circ_{1225}=0.5$ kcal with an estimated uncertainty of ±1 kcal for both the above all-monomer reactions.

11028. Kropschot, R. H., **Report on the fourteenth cryogenic engineering conference,** *Cryogenics* **8,** No. 6, 346-348 (Dec. 1968).

Key words: Cryogenics; cryogenic engineering conference.

Delegates from the United States and 6 foreign countries assembled in Cleveland, Ohio, August 19-21, 1968 to discuss new advances in cryogenics. The Case Western Reserve University was host to the 14th Annual Cryogenic Engineering Conference. The technical program was divided into 12 technical sessions and eight seminars. This review presents the highlights of the conference.

11029. Ku, H. H., **Expressions of imprecision, systematic error, and uncertainty associated with a reported value,** *Meas. Data* **2,** No. 4, 72-77 (July-Aug. 1968).

Key words: Accuracy; calibrations; expression of uncertainty; measurements; precision; standard error; systematic error; uncertainty.

The work of a calibration laboratory is described in terms of a sequence of operations that results in the collection, storage and transmittal of information. Since the information content of the statements of uncertainty determines the worth of a reported value, these statements deserve to be well formulated. An annotated guide to such commonly used expressions of uncertainties is given in table form for convenient reference.

11030. Kuehner, E. C., Freeman, D. H., **Containers for pure substances,** Chapter in *Purification of Inorganic and Organic Materials,* M. Yief, ed., pp. 297-306 (Marcel Dekker Inc., New York, N.Y., 1969).

Key words: Container impurities; pure containers.

This is a brief discussion and summary of criteria used in the selection of a pure container for pure chemical substances. The various sources of contamination are classified according to container purity, container stability, and container inertness. A brief discussion of container cleaning is included. A tabular summary of various container materials is presented according to the relevant sources of container imperfection or failure.

11031. Kuriyama, M., **Theory of x-ray diffraction by a distorted crystal. II. Scattering amplitude for a wave packet of finite size,** *J. Phys. Soc. Japan* **25,** No. 3, 846-856 (Sept. 1968).

Key words: Atom; displacement; distorted crystal; energy flow; finite beam; theory; wave field; wave packet; x-ray diffraction.

The x-ray scattering amplitude for a finite wave packet diffracted by a distorted crystal has been calculated by the use of a previously formulated theory (M. Kuriyama, J. Phys. Soc. Japan **23,** 1369 (1967)). An approximation used for deriving the final expression of the scattering amplitude is that the lateral sizes of an incident beam of ordinary x-ray energy are greater than several hundred microns. When the beam is finite in its lateral size, only a limited portion of the crystal is responsible for scattering. The geometrical arrangement of the limited region has been discussed in terms of an observation point on the crystal exit surface, an incident (glancing) angle and an observation (detector) angle. The internal wave fields and paths of classical energy flow are also discussed from the viewpoint of the present formulation.

11032. Kushner, L. M., **The National Bureau of Standards and the Fire Research and Safety Act of 1968,** *Fire J.* **62,** No. 5, 32-33, 118 (Sept. 1968).

Key words: Fire research; fire technology.

The National Bureau of Standards, which has a long history of activity in the fire research field, will have broadened responsibilities under the terms of the Fire Research and Safety Act of 1968. NBS will not only serve as a research resource, but as a center for administration in new areas of work including technical application to reduce fire losses. The Bureau will seek to avoid duplication of activities underway, and views the new program as a cooperative attack of Government and the private sector on the national fire problem. The levels of activity attained will depend on funding provided, and the short term objective will be to initiate projects for using existing technology to the fullest for reducing losses and improving fire services effectiveness. The development of new techniques for reducing fire losses is a longer term objective.

11033. Kusuda, T., **Thermal response factors for multilayer structures of various heat condition systems,** *ASHRAE Trans.* **75,** No. 1, V.3.1-V.3.25 (1969).

Key words: Cylinder; multilayer structures; response factors; sphere; transient head conduction.

The thermal response factor method for calculating transient heat conduction through multilayer slabs is generalized to include the solutions for many other important engineering heat transfer problems. Response factor formulas for multilayer structures of cylindrical and spherical objects (hollow as well as solid), plane and curved surface walls adjacent to infinitely thick heat conduction medium, such as ground, and plane slabs are presented in this paper. Numerical evaluation of these formulas are carried out for selected multilayer structures and the results are tabulated.

11034. Kuyatt, C. E., **Measurement of electron scattering from a static gas target,** Chapter 1 in *Methods of Experimental Physics.* **Vol. 7.** *Atomic and Electron Physics, Electron-Atom Interactions,* B. Pederson and W. L. Fite, eds., pp. 1-43 (Academic Press Inc., New York, N.Y., 1968).

Key words: Absolute electron energy; calculation of scattering geometries; differential electron scattering cross section; Doppler broadening; elastic electron scattering cross sections; electron multiplier; Faraday cup; generalized oscillator strength; inelastic electron scattering cross section; scattering chambers; transmission of energy analyzers.

The quantitative aspects of the measurement of elastic and inelastic scattering of electrons from static gas targets is discussed. Basic arrangements for the measurement of total and differential cross sections are reviewed, followed by a critical discussion of the calculation of scattering geometries, of the transmission of energy analyzers, of Faraday cup electron collectors, and of electron multiplier detectors. Other topics treated are scattering chambers, use of generalized oscillator strengths to express cross section data, Doppler broadening of energy distributions, pressure variation of scattered signals, and calibration methods for cross section and absolute electron energy.

11035. Lafferty, W. J., Maki, A. G., Pringle, W. C., Jr., **Comments on "two rotational lines of allene C_3H_4,"** *J. Chem. Phys.* **50,** No. 1, 564-565 (Jan. 1, 1969).

Key words: Allene; E vibrational state; microwave spectrum; rotational transitions; Stark effect; vibrational states.

Goertz (J. Chem. Phys. **48,** 523 (1968)) has claimed to have observed two rotational lines of allene arising from $J=3 \rightarrow 4$ transitions in the $K=0$ levels of the vibrational states of allene. A number of theoretical considerations are presented which cast doubt on the validity of Goertz's assignment of these lines to allene. A thorough search of the microwave spectrum of allene in the regions where the lines resulting from the $1 \rightarrow 2$ and the $3 \rightarrow 4$ transitions should fall produced no evidence for the lines observed by Goertz.

11036. Lance, H. W., **Metrology and national goals,** (Proc. 22nd ISA Conf. and Exhibit, Chicago, Ill., Sept. 11-14, 1967), *ISA Preprint* No. M4-1-MESTIND-67, 1-14 (1967); excerpt in *Meas. Data* **2,** No. 2, 68-71 (Mar.-Apr. 1968).

Key words: Calibration; cost-effectiveness; data; economic growth; information centers; measurements; metrology; National Bureau of Standards; National Measurement System; National Standard Reference Data System; Radio Standards Laboratory; reference data.

The ability to measure accurately and reliably is vital to the advancement of science and technology, and advanced science and technology are more and more essential in our large national programs. Therefore metrology is of prime importance to the achievement of national goals. Measurements in the United States take place within a loosely organized measurement system, which is not working as well as it should. Hence there are unnecessary expenditures of time and money on our national programs. The system could be improved by establishing comprehensive information centers, adopting new approaches to calibration, and implementing an existing standard reference data plan. However, carrying out these tasks will require additional resources for metrology. Funding problems arise because neither the layman nor the manager understand well the role of measurements, and the metrologist lacks data for demonstrating quantitatively the economic impact of his work. Therefore metrologists need to help the economists devise better ways of getting economic data on measurements and to mount a program for better understanding of the role of measurements, especially by policy makers. Such action would provide a basis of better national planning for measurements and exploitation of measurements for the economical attainment of national goals.

11037. Lang, S. B., Shaw, S. A., Rice, L. H., Timmerhaus, K. D., **Pyroelectric thermometer for use at low temperatures,** *Rev. Sci. Instr.* **40,** No. 2, 274-248 (Feb. 1969).

Key words: Calorimetry; cryogenics; dielectric constant; ferroelectric ceramic; pyroelectric coefficient; thermometry; volume resistivity.

The applicability of pyroelectric thermometry to temperature change or temperature rate measurement at cryogenic levels was studied, with particular emphasis on calorimetry. The pyroelectric coefficients, dc dielectric constants, and volume resistivities of three ferroelectric ceramic materials, Clevite Ceramic B, PZT-4 and PZT-5A, were measured over the temperature range 4.2 to 300 °K The pyroelectric coefficients were found to be reproducible, but large electric fields, thermal shock, and aging affected the pyroelectric coefficient. Expressions are derived for the temperature responsivity (voltage output per unit temperature change), noise equivalent temperature change (temperature change equivalent to the electrical noise in a pyroelectric thermometer), and figure-of-merit (a parameter characterizing the physical properties of a pyroelectric material). Typical temperature responsivities of 8.0 and 165 volts/°K, and values of noise equivalent temperature change of 2.5 and 0.12 microdegrees K, at 5 and 300 °K respectively, are calculated. Recommendations concerning the usage of a pyroelectric thermometer in a cryogenic calorimeter are given.

11038. Lashof, T. W., **Standardization and application of accuracy and precision statements: TAPPI Standards Committee – ASTM Committee D-6 policy,** *Tappi* **4,** 732-739 (Apr. 1969).

Key words: Accuracy; paper; precision; standards; test methods.

This paper states the present policy for the use of the terms precision and accuracy for TAPPI and ASTM D-6 Standards and Suggested Methods. Several questions involved in establishing the policy are discussed. Brief examples show how to compute precision from available data, how to state the precision of a test method, and how to apply this information in practical cases.

11039. Latanision, R. M., Staehle, R. W., **Plastic deformation of electrochemically polarized nickel single crystals,** *Acta Met.* **17,** 307-319 (Mar. 1969).

Key words: Active potentiais; critical resolved shear stress; near surface dislocation sources; passive potentials; single crystals.

Nickel single crystals were deformed in uniaxial tension under active and passive conditions in a 1N H_2SO_4 solution at room temperature. τ_0 increases and Stages I and II are suppressed in the presence of the thin passive film formed at 800 mV (SCE). In contrast, surface removal prior to deformation lowers τ_0 in comparison to crystals deformed in the laboratory atmosphere. Continuous surface removal during deformation only slightly affects θ_I, but does increase the extent of easy glide and Stage II. Abrupt changes in the stress for further plastic deformation occur when crystals are unloaded and held at constant potential in interrupted tests. Electron microscope studies of surface replicas show that slip lines formed under dissolution conditions are stronger and more widely spaced than those produced on crystals deformed in air. The spacing and step height on passivated crystals appear to be intermediate between two extremes. A model of plastic deformation based upon the activation of *near surface* dislocation sources is presented in the context of the above observations.

11040. Laufer, A. H., **Photolysis of ketene. Mechanism of hydrogen production and the reaction of methylene with methane,** *J. Phys. Chem.* **73,** No. 4, 959-963 (Apr. 1969).

Key words: Excited state; hydrogen formation; ketene; methylene; photodecomposition.

The photolysis of ketene has been investigated at photon energies from 3130 Å (3.96 eV) to 1470 Å (8.43 eV). Hydrogen is produced at all wavelengths. Based upon the photolysis of CD_2CO-CH_2CO mixtures the reaction

$$CH_2CO \rightarrow H_2 + C_2O$$

is suggested as a primary process.

The sequence of reactions (1) and (2) has also been examined.

$$CH_2 + CH_4 \rightarrow C_2H_6^* \tag{1}$$

$$C_2H_6^* \rightarrow H_2 + C_2H_4 \tag{2}$$

It is concluded that of the decomposition paths available to $C_2H_6^*$ fewer than 6 percent proceed via reaction (2) over a wide energy range. The significance of this finding with respect to the photodecomposition of methane is discussed.

11041. Laufer, A. H., McNesby, J. R., **Photolysis of methane at 1236-A: quantum yield of hydrogen formation,** *J. Chem. Phys.* **49,** No. 5, 2272-2278 (Sept. 1, 1968).

Key words: Isotope effect; methane; quantum yields; vacuum ultraviolet.

Pure CH_4 and CD_4 have been separately but simultaneously photolyzed at 1236 Å by means of a split cell technique in order to obtain accurate relative quantum yields for the various modes of production of H_2 and D_2. The split cell technique has been used to obtain absolute quantum yields by comparison with the CO_2 actinometer. Molecular elimination yields for CD_4 and CH_4 (0.58) are found to be nearly equal while the H atom yield greatly exceeds the D atom yield. It is concluded from the results that a significant fraction of the atoms produced disappears by the association reaction $M + H + CH_3 \rightarrow CH_4 + M$. The effect of scavengers and inert gas have been studied and the absolute quantum yields measured by comparison with the CO_2 actinometer. The total quantum yield for H and H_2 formation is at least 1.29 and fragmentation of CH_2 or CH_3 formed in the primary process is suggested.

$$CH_3 \rightarrow H + CH_2$$

$$CH_2 \rightarrow H + CH$$

However, the lower limit for the quantum yield for D and D_2 formation is 0.76 and evidence for fragmentation of CD_2 or CD_3 is absent.

11042. Lederer, P. S., **Pressure,** Chapter 1 in *ISA Transducer Compendium,* Part 1, 2nd ed., pp. 5-8 (1969).

Key words: Evaluation; measurement; performance; pressure; test methods; transducer calibration.

A chapter for the "ISA Transducer Compendium" briefly introducing the reader to the field of pressure and its measurement by means of electrical output transducers. The purpose of this chapter is to assist the reader to select the transducer most suitable for his application from those listed in the compendium.

11043. Lee, T. G., **A system for continuously monitoring hydrogen chloride concentrations in gaseous mixtures using a chloride ion-selective electrode,** *Anal. Chem.* **41,** 391-392 (Feb. 1969).

Key words: Aerosol; chloride selective electrode; decomposition product; HCl gas analyzer; polyvinyl chloride.

A continuous recording aqueous chloride ion concentration analyzer for the determination of HCl in gas and aerosol samples is described. It consists of a gas scrubber to absorb the HCl in the gas sample and a chloride-ion selective electrode of the ion exchange type to measure the chloride ion in solution. At a gas sampling rate of 100 cm^3/min, range of detection was about 20-10,000 ppm HCl; reproducibility was within ±5 percent and time of response to 99 percent of equilibrium was about 1.5 min.

11044. Levin, E. M., **X-ray determination of the thermal expansion of silver nitrate,** *J. Am. Ceramic Soc.* **52,** No. 1, 53-54 (Jan. 1969).

Key words: $AgNO_3$; density $AgNO_3$; polymorphism $AgNO_3$; thermal expansion $AgNO_3$; unit cell dimensions $AgNO_3$.

An x-ray diffractometer furnace was used to obtain powder patterns of orthorhombic (low) $AgNO_3$ between 25 and 140 °C and of rhombohedral (high) $AgNO_3$ between 25 and 175 °C. Unit cell dimensions are given for selected temperatures and are essentially a linear function of temperature. The values for the coefficient of expansion of low $AgNO_3$ along a, b. and c, respectively, are 126×10^{-6} deg^{-1}, 57×10^{-6} deg^{-1}, -0.4×10^{-6} deg^{-1}. For high $AgNo_3$ the values along a and c, respectively, are 30×10^{-6} deg^{-1} and 134×10^{-6} deg^{-1}. X-ray density of the high form at a given temperature is greater than that of the low form and, in general, does not agree with previous reported results. The value of dT/dP calculated from the Clausius-Clapeyron equation is -6.9×10^{-3} K/bar, at atmospheric pressure, vs Bridgman's experimental value of -7.6×10^{-3} K/bar.

11045. Lide, D. R., Jr., **Structure of the alkali hydroxides. IV. Interpretation of vibration-rotation interactions in CsOH and RbOH and refinement of structures,** *J. Chem. Phys.* **50,** No. 7, 3080-3086 (Apr. 1, 1969).

Key words: Alkali hydroxides; anharmonicity; force constants; microwave spectrum; molecular structure; vibration-rotation interaction.

The unusual vibration dependence of B_v in CsOH and RbOH is found to be due to a somewhat accidental cancellation of harmonic and anharmonic contributions to the interaction constant α_2. A rather different formulation of the vibration-rotation interactions in linear molecules, which explicitly takes into account the curvilinear nature of the motions, clarifies the physical reasons for the apparent anomalies in the microwave spectra of the alkali hydroxides. This formulation also shows that the dominant contribution to α_2 in most linear triatomic molecules is harmonic in nature and may be ascribed to the direct averaging of the moment of inertia over the harmonic bending vibration; this is in contrast to the usual viewpoint, in which the anharmonic contribution is considered dominant. All of the microwave and infrared data on CsOh and RbOh are consistent with a reasonable force field, although uncertainties in the harmonic force constants prevent a quantitative determination of anharmonic constants. In the absence of contrary evidence, we conclude that the alkali hydroxides very probably have a linear equilibrium configuration. The equilibrium bond lengths in CsOh are estimated to be: $r_{Cso}=2.391$ Å, $r_{OH}=0.96_0$ Å, in RbOH: $r_{Rbo}=2.301$ Å, $r_{OH}=0.95_7$ Å.

11046. Linzer, M., **Line parameters of Lorentzian curves containing arbitrary mixtures of absorption and dispersion,** *J. Appl. Phys.* **40,** No. 1, 372-376 (Jan. 1969).

Key words: Absorption-dispersion mixtures; Lorentzian lineshape; spectroscopy.

A brief description is presented of various ways in which mixed absorption-dispersion modes can arise. Exact closed-form solutions are derived for the line parameters of zeroth derivatives of Lorentz shape functions containing arbitrary mixtures of absorption and dispersion. The parameters are obtained as functions of ϵ, where ϵ represents the fractional admixture of one signal component relative to the other and may be determined experimentally from the signal amplitude asymmetry. Very simple expressions are also derived for the mixed first derivative curves if terms of the order of ϵ^3 and higher are neglected. In the case of the 1:1 admixture, this procedure introduces an uncertainty in the position of the line center of approximately 1 percent of the halfwidth of the pure absorption curve. The implications of this analysis for practical spectroscopic measurements are discussed. In particular, a very simple relationship is shown to exist between the degree of admixture and the experimental variables.

11047. Lipkin, H. J., Meshkov, S., **The importance of the $\eta\pi$ decay mode in the split A_2 decay,** *Phys. Rev. Letters* **2,** No. 5, 212-213 (Feb. 3, 1969).

Key words: A_2: boson; decay; octet; selection rule; symmetry.

If SU(3) symmetry is assumed and singlet-octet mixing is neglected, (a) the $\eta\pi$ decay mode is forbidden for all negative CP states including the $J^{P}=1^{-+}$ state suggested by the Gell-Mann Zweig model; (b) $\eta\pi$ cannot appear in decays where the $K\bar{K}$ mode is absent; (c) the $\eta\pi/K\bar{K}$ branching ratio is the same for all isovector octet bosons allowed to decay into $\rho\pi$. Violation of these predictions would imply either SU(3) symmetry breaking or a singlet contribution in the decay and suggest serious re-examination of other SU(3) decay predictions. Prediction (b) seems to be violated by preliminary data. If there are no violations and $\eta\pi$ and $\rho\pi$ are both allowed, the only possible classification for either A_2 peak with $J < 4$ is 2^{++}.

11048. Lippincott, E. R., Stromber, R. R., Grant, W. H., Cessac, G. L., **Polywater,** *Science* **164,** 1482-1487 (June 27, 1969).

Key words: Anomalous water; infrared spectrum of polywater; polywater; Raman spectrum of polywater; water.

The infrared and Raman spectra of a form of water prepared in quartz capillaries and previously designated as "anomalous" water have been obtained. The spectra appear to be unique with the apparent absence of the O-H stretching bands prominent in normal water spectra, and the appearance of new bands near 1600 and 1400 cm^{-1}. The interpretation is that new and previously unreported strong symmetric O-H-O bonds are formed, isoelectronic with FHF^-. The approximate bond distances are given as 2.3 Å for 0 · · · 0, and 1.5 Å for H-O. These bonds are regarded as responsible for the remarkable properties of the material and have considerable covalent character. These bonds are so strong that they cannot be considered as normal 0 · · · H hydrogen bonds. Extensive electron delocalization could occur in structures which involve oxygen atoms in three equivalent bonds. The bond energy per O-H-O unit is given as approximately 30-50 kcal/mole, and an energy of 60-100 kcal per H_2O structural unit. Several structures are proposed which are consistent with the spectral data and the remarkable properties and stability of the material. It is concluded that the material is a true polymer of water, and therefore named polywater.

11049. Little, W. E., Patty, O. L., Zanboorie, M. H., **A millimeter**

wave reflectometer, *IEEE Trans. Microwave Theory Tech.* **MTT-16,** No. 2, 121 (Feb. 1968).

Key words: Millimeter wave; reflectometer; WR-12 waveguide.

This paper describes a millimeter wave reflectometer system that has been developed in WR-12 waveguide. A detailed description of the system circuitry, a discussion of sources of measurement error and some measurement results are presented.

11050. Lloyd, E. C., **Erasable trace recording methods for chart recorders,** *Rev. Sci. Instr.* **39,** No. 12, 1953-1954 (Dec. 1968).

Key words: Automatic; chart recorders; erasable.

Citation of methods described in the technical and patent literature, and description of two new methods, for renewing the chart of closed-chart recorders by automatically removing the trace.

11051. Lloyd, E. C., **Standards for improved measurement of pressure and vacuum,** (Proc. 4th Intern. Measurement Conf., Warsaw, Poland, July 2-7, 1967), *Acta Imeko,* pp. 451-468 (Hungarian Academy of Sciences, Budapest, Hungary, 1967).

Key words: Accuracy; calibration; measurement; pressure; standards; vacuum.

Results of NBS developments are outlined in a number of projects relating to standards for improved measurement of pressures throughout the range from vacuum to very-high pressures. In the vacuum range this includes techniques for generation of stable reference pressures, and improved absolute instruments for force per unit area measurement down to 10^{-9} torr. In the range from a few millibars to hundreds of kilobars the use of fixed points, and the performance of improved piston gages and interpolation instruments, are described. Problems presently limiting accuracy of calibration and NBS investigations of possible solutions are mentioned. Two new "accuracy charts" are presented showing present and possible future NBS capabilities.

11052. Lloyd, E. C., Beckett, C. W., Boyd, F. R., Jr., **Measurements in the high-pressure environment,** *Science* **164,** 860-861 (May 16, 1969).

Key words: Equation of state; phase transformations as fixed points; pressure coefficients of thermocouples; pressure scale.

The highlights of the Symposium on Accurate Characterization of the High Pressure Environment are described. The Symposium was attended by 140 participants from the United States and abroad. Thirty-eight papers were presented and four panel sessions held covering current research at high pressures in static systems and in shock wave experiments. In panel sessions five fixed points below 100,000 bars were proposed, and values for these points recommended. The equation of state of sodium chloride was recommended as a standard for the x-ray determination of pressure. The measurement of temperature in high pressure apparatus and the measurement of phase transformations as a function of temperature and pressure using static and dynamic techniques were presented. Dynamic methods included studies of phase transformations ranging from 20,000 bars up to several million bars. Recent developments in the static high pressure techniques were also presented.

11053. Lutz, G. J., **Calculation of sensitivities in photon activation analysis,** *Anal. Chem.* **41,** No. 3, 424-427 (Mar. 1969).

Key words: Calculated sensitivities; cross section parameters; photon activation analysis; photon flux distribution; relative production rate; specific activities.

Estimates have been made of specific activities to be expected from bremsstrahlung produced by an electron accelerator. The photon flux distribution from electrons striking a 0.6 cm. tungsten target at different energies and included in the cone described by a five degree angle from the forward direction is calculated. Flux times cross section for photonuclear reactions of analytical utility was integrated and disintegration rates of the reaction products for most of the elements under conditions of different electron energies and irradiation times were calculated. Relative values for the specific activities were calculated and compared with the experimental results of Oka and co-workers and found to be in satisfactory agreement.

11054. McCaa, W. D., Jr., Nahman, N. S., **Phenomena and devices, frequency and time-domain analysis of a superconductive coaxial line using the two fluid model,** *J. Appl. Phys.* **39,** No. 6, 2592-2596 (May 1968).

Key words: Frequency response; Gorter-Casimir two fluid model; step response; superconductive coaxial line.

A miniature 80-ft superconductive coaxial line (Nb inner conductor 0.01 in. od, Pb outer conductor 0.034 in. i.d., polytetrafluoroethylene dielectric) has been analyzed in terms of the Gorter-Casimir two-fluid superconductivity model, considering the anomalous and classical cases (without relaxation effects) for the normal components. The dielectric and the metal flux trapping losses are assumed to be negligible. The 10^6-10^{12} Hz line attenuation and the 1-100 psec step responses are presented for the temperature range of 2.3-10 °K. Predictions are compared with the experimental results of several independent investigators. It is concluded that if the dielectric and the metal flux-trapping losses are negligible, then (1) the model provides bounds between which the responses of physically realized lines will fall, and (2) the normal conductivity of the conductors must be very good if the maximum bandwidth and minimum risetime are to be obtained.

11055. McCamy, C. S., **A half century of photographic standardization in the United States,** *Photo. Sci. Engr.* **12,** No. 6, 308-312 (Nov.-Dec. 1968).

Key words: Motion picture standards; photographic standards.

Over the past 50 years, photography and cinematography have reached a high level of standardization in the United States of America. This has been accomplished through cooperative efforts of the photographic industry, interested consumers, and the government. These efforts have been organized by societies such as the Society of Motion Picture and Television Engineers, and by the United States of America Standards Institute and its predecessors. The USA program is coordinated with those of other nations by the International Organization for Standardization. Besides the documentary standards which record the consensus of interested parties with regard to specifications and test methods, there are physical standards, from various sources, which serve as the basis of measurement.

11056. McCamy, C. S., **Photographic image structure evaluation,** Chapter in *Ultra-Microminiaturization Precision Photography for Electronic Circuity,* pp. 130-140 (Society for Photographic Scientists and Engineers, Washington, D.C., 1968).

Key words: Photochemical fabrication; photographic image structure.

Photographic images are usually evaluated with respect to visual applications. Photochemical fabrication can benefit from the accumulated experience in this field, but introduces its own complications. The kind of optical density to be used or measured must be precisely known. The nature of light limits the amount of detail that can be reproduced. Photographic materials are limited with respect to resolving power, acutance, and granularity. These quantities can be useful in evaluating photochemical fabrication systems. Although modulation transfer theory has been applied to photographic systems, nonlinearities raise problems which may require more rigorous treatment.

11057. McCamy, C. S., **Units for logarithmic scales,** *Phys. Today* **22,** No. 4, 42-44 (Apr. 1969).

Key words: Brigg; logarithmic scales; octave; optical density; order; symbols; units.

The following definition is proposed: If $\log_b(a/c) = n$, then a is n orders to base b greater than c. One order is regarded as a unit of a logarithmic scale, the symbol ord_b is proposed, and a number of existing applications are described in these terms. The brigg (symbol: Br) is recommended as the name of one order to base 10. The symbols oc and st are recommended for octave and step.

11058. McClintock, M., Jennings, D. A., Mizushima, M., **Contribution to the Raman line profile in liquids from molecular reorientation,** *Phys. Rev. Letters* **21,** No. 5, 276-278 (July 29, 1968).

Key words: Benzene; carbon tetrachloride; Raman scattering.

The profiles of several Raman lines arising from nontotally symmetric molecular vibrations in liquid benzene and carbon tetrachloride have been measured using 4880 Å radiation from an argon ion laser as a source of illumination. These profiles have been analyzed on the assumption that scattering occurs from time-dependent molecular reorientations of small angle in the liquid, analagous to those producing depolarized scattering at the Rayleigh line. On this basis, the half width at half maximum of the 606 cm^{-1} Raman line in benzene was found to be 3.3 cm^{-1}, and the half width of the "orientation" line underlying this Raman line was found to be 24.3 cm^{-1}. The rotational relaxation time calculated for the ν_{18} vibrationally excited molecule is therefore 1.38×10^{-12} seconds. This short compared with a period of rotation and supports the assumption of rotational Brownian motion. It is also shorter than the rotational relaxation time for the molecule in the ground vibrational state, and indicates that there is weaker rotational coupling between molecules in the ground state than between vibrationally excited molecules and those in the ground state. The depolarization ratios of the Raman and the orientation components of the 606 cm^{-1} line for linearly polarized incident light were found to be 0.748 and 0.749 respectively, in agreement with the theoretically predicted 0.750.

11059. McIntyre, D., Mazur, J., Wims, A. M., **Effects of excluded volume on light scattered from flexible macromolecules,** *J. Chem. Phys.* **49,** No. 7, 2887-2895 (Oct. 1, 1968).

Key words: Chain-end distribution; excluded volume; light scattering; particle scattering factor; polydispersity.

The effect of the non-Gaussian behavior of the chain segment distribution in flexible polymer coils on the angular distribution of scattered light is discussed. The explicit form of a general spherical segment distribution function,

$$W(r.N)dr = \frac{t}{\Gamma(3/t)}\left[\frac{\Gamma(5/t)}{\Gamma(3/t)\,\langle R_N^2\rangle}\right]^{3/2} \exp - \left[\frac{\Gamma(5/t)r^2}{\Gamma(3/t)\,\langle R_N^2\rangle}\right]^{t/2} r^2dr,$$

with different values of t, is used to evaluate the general scattering equation for the particle scattering factor P(Θ).

$$P(\Theta) = \frac{1}{N^2}\sum_{i>j}\sum \frac{\sin Ksr_{ij}}{ksr_{ij}}.$$

In addition, the effects of excluded volume on the mean end-to-end chain separation $\langle r^2_N\rangle$ is taken to be of the form $\langle r^2_N\rangle \approx N^{1+\epsilon}$, where N is the number of chain steps and ϵ is a parameter, which measures the excluded volume effect on the $\langle r^2_N\rangle$. In this paper, an expansion of the P(Θ) function to the first few terms is carried out and numerically evaluated for the dependence of P(Θ) on the variable x, where $x = ks\langle r_{exp}\rangle$, k is the wave number of the incident light, s is related to the scattering angle and $\langle r_{exp}\rangle$ is the radius of gyration determined from experimental data of the scattering cross section. The computations were carried out for the polymer in good solvent, for which data for ϵ and t were adopted, based on the lattice model of non-self intersecting chain, and for polymer in theta solvent, for which Gaussian chain model was adopted. The computations were carried out for various degrees of polydispersity. A comparison was made between the theoretical and the experimental results on a polystyrene sample of molecular weight of 4.10^6 in cyclohexane at 35, 45, and 55 °C, and in benzene at 40 °C.

11060. McIntyre, D., Sengers, J. V., **Study of fluids by light scattering,** Chapter 11 in *Physics of Simple Liquids,* H. N. V. Temperley, J. S. Rowlinson, G. S. Rushbrooke, eds., pp. 449-505 (North Holland Publ. Co., Amsterdam, The Netherlands, 1968).

Key words: Brillouin scattering; critical opalescence; fluctuations; gases; light scattering; liquids; Rayleigh scattering.

After introducing the basic scattering equations, the first part of the paper is devoted to a discussion of measurements of the intensity of scattered light. A survey is presented of the experimental verification of the Einstein scattering equations. Furthermore, the experimental angular dependence of the scattered intensity near the critical point is discussed, in particular for binary liquid mixtures near the critical mixing point.

The second part of the paper is devoted to the spectrum of scattered light. The Landau-Placzek theory, as worked out by Mountain, is discussed in detail for one component fluids and estimates are presented for several characteristic properties of the spectrum as a function of density and temperature. The experimental verification of the Landau-Placzek theory is surveyed. The paper concludes with a discussion of the spectrum of critical opalescence.

11061. McKinley, J. D., Jr., **Mass spectrometric investigation of the surface reaction of tungsten with chlorine-oxygen mixtures,** (Proc. 6th Intern. Symp. Reactivity of Solids, Schenectady, N.Y., Aug. 25-30, 1968), Chapter in *Reactivity of Solids,* J. W. Mitchell, R. C. DeVries, R. W. Roberts, and F. Cannon, eds., pp. 345-351 (John Wiley and Sons, Inc., New York, N.Y., 1969).

Key words: Chlorine; high temperature; mass spectrometry; oxygen; reaction kinetics; tungsten.

The rapid erosive attack of chlorine, oxygen mixtures on hot tungsten has been studied mass spectrometrically. At surface temperatures between 1000 and 2400 K the major product is gaseous tungsten dioxydichloride. Volatile tungsten dioxide and trioxide also form at lower rates. Oxide desorption exhibits the same pressure and temperature dependence as in pure oxygen. No evidence was obtained for simple tungsten chlorides or for chlorine oxides among the products.

11062. McNesby, J. R., Kelley, R. V., **High temperature vacuum ultraviolet photolysis of n-butane,** *J. Phys. Chem.* **73,** No. 4, 789-793 (Apr. 1969).

Key words: Chain reaction; n-butane; n-butane-d_{10}; photolysis; vacuum ultraviolet.

Mixtures of n-butane and n-butane-d_{10} have been photolyzed at 1470 Å over the temperature range 35-398 °C. The mechanism of methane formation is shown to be largely intramolecular at 35 °C and becoming increasingly dominated by a chain reaction carried by methyl radicals as the temperature is raised. At 398 °C, the mechanism of methane formation is almost entirely free radical. Estimates have been made of average chain lengths as a function of temperature and from this, the chain length in the pyrolysis of n-butane is calculated to be about 2000. It is suggested that none of the methods of detecting molecular elimination of methane in the pyrolysis of butane have been sufficiently sensitive. Molecular elimination of methane in pyrolysis may be at least as important as methyl radical formation and still escape detection.

11063. Macedo, P. B., Napolitano, A., **Inadequacies of viscosity theories for B_2O_3,** *J. Chem. Phys.* **49,** No. 4, 1887-1895 (Aug. 15, 1968).

Key words: Activation energy; Arrhenius behavior; B_2O_3 glass; configuration entropy; distribution of relaxation times; free volume; Fulcher equation; viscosity.

The viscosity of B_2O_3 glass was measured from 10^{10} to 10^{14} poises by the fiber elongation method and found to be Arrhenius with an activation energy of 94 kcal/mol. These new data were combined with previously reported rotation data (10^1 to 10^{10} poises) and gave a smooth plot. Considering the best known viscosity theories, in view of the new additional viscosity data, and finding no reasonable fits, an examination of the validity of the basic assumptions underlying these theories was made. As a result of this study, it was found that the temperature dependence of the viscosity is not controlled by structural effects such as free volume, configuration entropy, etc. but by activation energy effects in the viscous flow process. The onset of the non-Arrhenius region is a direct consequence of the appearance of a symmetric distribution of relaxation times and/or a distribution of activation energies which can not be explained by existing viscosity theories. Finally, all theories are in error in predicting that the viscosity goes to infinity (in the annealing region) much faster than the measured values indicate.

11064. Macedo, P. B., Simmons, J. H., Haller, W., **Spectrum of relaxation times and fluctuation theory: ultrasonic studies on an alkali-borosilicate melt,** *Phys. Chem. Glasses* **9,** No. 5, 156-164 (Oct. 1968).

Key words: Alkali-borosilicate glass; composition fluctuations; immiscible alkali-borosilicate glass; spectrum of relaxation times; ultrasonic relaxation.

Ultrasonic relaxation measurements (3 to 23 MHz and 750 to 1200 °C) were made using shear waves on a molten glass of 6.72 percent Na_2O, 25.31 percent B_2O_3 and 67.97 percent SiO_2 with a solubility temperature of 749 °C. The spectrum of shear relaxation times was determined between 840 and 1200 °C, where it was found to be highly temperature dependent. A model was proposed which predicts the observed temperature dependence of the spectrum in terms of composition fluctuations. The model is based upon the concept that the activation energy of a molecule depends on the environment within a sphere of radius r_0 about the molecule. The value of $r_0 \sim 50$ Å obtained from the supercritical composition fluctuations is of the same order as sizes of microheterogeneities directly observed with an electron microscope in single oxide glasses by other workers.

11065. Madden, R. P., Ederer, D. L., Codling, K., **Resonances in the photoionization continuum of Ar I (20-150 eV),** *Phys. Rev.* **177,** No. 1, 136-151 (Jan. 5, 1969).

Key words: Absorption cross-section; absorption spectra; argon; photoionization; vacuum ultraviolet.

The absorption spectrum of argon in the region 20-150 eV has been studied photographically and photoelectrically, using synchrotron light as a background source and a resolution of 0.06 Å. Many resonances have been observed in the photoionization continuum which are caused by electronic excitation to high autoionizing states of Ar I. In the region between 27 and 40 eV the observed structure is due to two types of electronic excitation: (i) the excitation of a single sub-shell 3s electron, resulting in the configuration $3s3p^6np$ and (ii) the excitation of two of the outer 3p electrons simultaneously, resulting in configurations of the type $3s^23p^4n\ell n'\ell'$. Between 44 and 59 eV weak structures have been observed in the absorption continuum due to the simultaneous excitation of a 3s and a 3p electron, resulting in configurations of the type $3s3p^5n\ell n'\ell'$. All of the observed resonances have been tabulated, and a partial classification has been given. The profiles of the resonances caused by transitions to states $3s3p^6(^2S_{1/2})np\ ^1P_1^\circ$, for n=4, 5, and 6, and the two electron excitation states $3s^23p^4(^3P)4s(^2P_{3/2})4p$ and $3s^23p^4(^3P)3d(^2P_{3/2})4p$, have been studied quantitatively. The values of q, ρ^2, and Γ have been determined for each of these resonances, and the continuum cross-section has been measured between 24 and 36 eV.

11066. Mopsik, F. I., **Dielectric properties of slightly polar organic liquids as a function of pressure, volume, and temperature,** *J. Chem. Phys.* **50,** No. 6, 2559-2569 (Mar. 15, 1969).

Key words: Carbon disulfide; carbon tetrachloride; Clausius-Mossotti; density; dielectric constant; dipole moment; isopentane; polarizability pressure; slightly polar liquids; Tait equation; toluene.

The dielectric constant and density have been measured simultaneously for carbon tetrachloride, carbon disulfide, isopentane and toluene. The Clausius-Mossotti polarization for all liquids at constant temperature shows a linear decrease with density. Only isopentane and toluene show a temperature dependence of the Clausius-Mossotti polarization at constant density consistent with the presence of a permanent dipole moment. The dipole moments derived from the constant density data are 0.105 D for isopentane and 0.332 D for toluene. Also, the Bottcher-Onsager equation is shown to be incompatible with the measured data.

11067. Mopsik, F. I., **The effect of pressure, volume and temperature on the dielectric constant of simple organic liquids,** *Proc. 1967 Annual Report Conf. Electrical Insulation and Dielectric Phenomena, Buck Hill Falls, Pa., Sept. 18-20, 1967,* pp. 66-69 (Natl. Acad. Sci.—Natl. Res. Council, Washington, D.C., 1968).

Key words: Carbon disulfide; carbon tetrachloride; density; dielectric constant; n-hexane; polarizability; pressure.

Measurements have been made on carbon tetrachloride, carbon disulfide and hexane over a wide range of temperature and pressure for both density and dielectric constant. For all liquids there is a general decrease in the polarizability with an increase in density. N-hexane alone has shown a temperature dependence of its dielectric constant consistent with a dipole moment.

11068. Mountain, R. D., Deutch, J. M., **Light scattering from binary solutions,** *J. Chem. Phys.* **50,** No. 3, 1103-1108 (Feb. 1, 1969).

Key words: Binary mixtures; Brillouin scattering; diffusion coefficient; light scattering; optical mixing spectroscopy; Rayleigh scattering.

The spectrum of the light scattered by a binary solution is calculated from thermodynamic fluctuation theory and the linearized hydrodynamic equations appropriate to a two component fluid. The spectrum consists of three peaks. Expressions are obtained for the positions and widths of the two side, Brillouin peaks. In general the central, unshifted Rayleigh peak is found to consist of a superposition of two Lorentzians that involve the combined dynamical effects of heat conduction and diffusion. The condition is stated under which it is possible to separate the central peak simply into two contributions, one arising from diffusion and one from thermal conduction. For many binary systems this separation is justified. In these cases measurement of the spectrum of the scattered light should prove to be an attractive alternative means of measuring the diffusion coefficient of binary solutions.

11069. Mozer, B., **Localized modes, resonant modes and impurity vibrational bands in vanadium alloys,** Chapter in *Neutron Inelastic Scattering* **1**, 55-63 (International Atomic Energy Agency, Vienna, Austria, 1968).

Key words: Alloys; bound states; inelastic neutron scattering; local modes; resonant modes.

Inelastic neutron scattering data have been obtained on Be-V, Ta-V, W-V, Ni-V, and Cr-V alloys in a search for defect modes of vibration, impurity vibrational bands, and effects on the vibrational spectrum arising from perturbed electron energy bands in some of these alloys. The results of these experiments show for the light mass beryllium atoms a single localized mode at 0.047 eV at low concentration and in agreement with theory for an isotopic defect; impurity bands with structure are observed at higher concentrations. A decay constant of $2.5\ a_o^{-1}$ for the amplitude of a localized mode can be obtained from the observed splitting. Evidence is scant for resonant modes from heavy mass atoms in vanadium as observed in the very small difference between alloy vibrational spectra and the pure vanadium spectrum. Very small peaks are observed corresponding to a splitting of the resonant modes with no theoretical explanation available. Ni-V and Cr-V alloys of equal electron concentration show similar spectra but differing greatly from the pure vanadium spectrum. Arguments on how the electron density influences the magnitude of the high frequency vibrational spectra of the ions provide an indirect proof of the absence of bound electron states (localized states) associated with nickel ions in vanadium.

11070. Munis, R. H., Finkel, M. W., **Goniometric measurements of infrared transmitting materials,** *Appl. Opt.* **7,** No. 10, 2001-2004 (Oct. 1968).

Key words: Angular scattering instrument; infrared scattering; polycrystalline scattering.

An angular infrared scattering instrument has been constructed. Measurements at infrared wavelengths have been made on a polycrystalline specimen. A radiative balance equation has been written and an angular scattering function has been defined. The total scattered radiation is calculated by summation of the scattering function over all solid angles.

11071. Nemoto, T., Wait, D. F., **Microwave circuit analysis using the equivalent generator concept,** *IEEE Trans. Microwave Theory Tech.* **MTT-16,** No. 10, 866-873 (Oct. 1968).

Key words: Cascaded multiports; equivalent generator; generalized reflectometers; multiports; reduced multiports; scattering matrix analysis.

To facilitate a scattering matrix analysis of complicated microwave circuit problems, an equivalent generator approach has been developed. The equivalent generator parameters are stated in terms of the parameters of the actual circuit elements. These statements are expressed in terms of special determinants which make the results easier to remember, and easier to use. Three different types of problems are solved to demonstrate the utility of the method; the response from generalized reflectometers, the properties of cascaded multiports in terms of its elements, and the properties of multiports whose number of available ports have been reduced.

11072. Newman, M., **Maximal normal subgroups of the modular group,** *Proc. Am. Math. Soc.* **19,** No. 5, 1138-1144 (Oct. 1968).

Key words: Linear fractional groups; maximal normal subgroups; simple groups.

The principal results of this paper are: (1) the modular group Γ contains infinitely many maximal normal subgroups of finite index which are not congruence groups, and (2) any element of LF(2,q) other than $\pm I$ may be written as the product of an element of period 2 and an element of period 3, provided that $p > 3$, where $q = p^n$.

11073. Nimeroff, I., **A survey of papers on degree of metamerism,** *Color Eng.* **6,** No. 6, 44-46 (Nov.-Dec. 1968).

Key words: Colorimetric matches; colorimetry; color vision; index of metamerism; metamerism; spectrophotometric matches.

Generally, colorimetric matches are metameric, not spectral. The degree of metamerism between a pair of metameric colors is determined by the differences between the spectral distributions of light from these colors. A survey of work reported on metamerism revealed that colorimetric indexes of metamerism have been devised on the basis of observed color differences that appear with change of illuminating and viewing conditions. These indexes are, however, limited in scope and applicability. A general and fundamental metamerism index should depend directly on the spectral differences of the matched metameric colors. A description is given of an index of metamerism that depends directly on spectral differences, is independent of color lightness, and correlates well with the spread of chromaticity coordinates of metameric matches made by a number of observers for a variety of colors.

11074. Norton, R. B., **Aeronomy,** *Encyclopedia of Atmospheric Sciences and Astrogeology,* R. W. Fairbridge, ed., pp. 3-7 (Reinhold Publ. Co., New York, N.Y., 1967).

Key words: Aeronomy; atmosphere; atmospheric; structure; theory.

The definition and general scope of aeronomy is indicated and the division of the atmosphere into regions is discussed. Atmospheric structure and theory is briefly reviewed.

11075. Okabe, H., **Photodissociation of HN_3 in the vacuum-ultraviolet production and reactivity of electronically excited NH,** *J. Chem. Phys.* **49,** No. 6, 2726-2733 (Sept. 15, 1968).

Key words: Absorption spectrum; $A^3\Pi_i$; fluorescence; fluorescence quenching; HN_3; NH $c^1\Pi$; photodissociation; vacuum ultraviolet.

Photodissociation processes of HN_3 yielding electronically excited species have been studied in the vacuum ultraviolet. The fluorescence originating from these species has been investigated in the spectral region from 1700 to 6000 Å. The predominant excited species are NH $c^1\Pi$, NH $A^3\Pi_i$ and probably N_2 $B^3\Pi_g$. The yield of the NH $c^1\Pi$ is produced mainly in $v = 0$ levels with only 7 percent in $v = 1$ levels both at the Kr and Xe lines. However, it is rotationally excited up to $K = 18$. Direct formation of the NH $A^3\Pi_i$, a spin forbidden process, appears to be minor. The pressure dependence of the ratio, NH $A^3\Pi_i$ to NH $c^1\Pi$, indicates that the NH $A^3\Pi_i$ may be formed largely by the reaction of electronically excited N_2, most probably N_2 $B^3\Pi_g$, with HN_3. The absorption coefficient of HN_3 has been measured in the vacuum ultraviolet region in order to examine its correlation with dissociation processes. It was concluded that the NH $c^1\Pi$ may be formed from predissociation of electronically excited HN_3 below 1450 Å, while above 1450 Å from direct dissociation. The NH $c^1\Pi$ is quenched almost in every collision with H_2, CO, O_2, and NO. It was found that the main quenching process by paramagnetic gases, O_2 and NO, is the conversion of the $c^1\Pi$ to the $A^3\Pi_i$. Other primary processes are discussed in conjunction with the present work.

11076. Olver, F. W. J., **Error bounds for the Laplace approximation for definite integrals,** *J. Approx. Theory* **1,** 293-313 (1968).

Key words: Asymptotic expansions; Bessel functions; definite integrals; error bounds; gamma function; Laplace approximation.

Explicit error bounds are obtained for the well-known asymptotic expansion of integrals of the form

$$\int_a^b e^{-\lambda p(x)} q(x) dx$$

in which λ is a large positive parameter, p(x) and q(x) are real differentiable functions, and p′(x) has a simple zero in the finite or infinite range [a,b]. The bounds are expressed in terms of the supremum of a certain function taken over [a,b], and are asymptotic to the absolute value of the first neglected term in the expansion as $\lambda \to \infty$. Several illustrative examples are given, including modified Bessel functions and the gamma function.

11077. Omar, A., Peterson, R. L., **On the validity of the Boltzmann relaxation equation,** *Physica* **39,** No. 1, 156-160 (July 1, 1968).

Key words: Boltzmann relaxation equation; Boltzmann transport equation; relaxation time approximation; transport theory.

A paper by Guénault and MacDonald, which shows that the "relaxation time approximation" is almost never strictly consistent with the "master equation," and which suggests that therefore this approximation can seldom be used in transport theory with confidence, is criticized. It is shown that the "Boltzmann relaxation equation" (BRE) in fact is often a direct consequence of the master equation in the steady state. We also point out that in those cases for which the BRE can be justified, the corresponding relaxation time is not generally sufficient in the Boltzmann transport equation if terms of higher order than the first in the driving field are desired.

11078. O'Reilly, D. E., Tsang, T., **On the order-disorder transition in ferroelectric ammonium sulfate,** *J. Chem. Phys. Letter to Editor* **50,** No. 5, 2274-2275 (Mar. 1, 1969).

Key words: Ammonium sulfate; deuteron magnetic resonance; ferroelectricity; neutron diffraction; order-disorder transition.

Divergent conclusions about the nature of ferroelectric transition in ammonium sulfate have been arrived at from the deuteron magnetic resonance and neutron studies. In this note, we review the evidence that the ferroelectric phase transition is an order-disorder phenomenon and suggest that the divergent conclusions are a result of the large thermal vibrations of the hydrogen atoms.

11079. Paabo, M., Bates, R. G., **Standards for a practical scale of pD in heavy water,** *Anal. Chem.* **41,** No. 2, 283-285 (Feb. 1969).

Key words: Acidity; carbonate; citrate; deuterium ion; deuterium oxide; glass electrode; heavy water; pD; phosphate; standards for pD.

The glass electrode has been found to respond to deuterium ion in heavy water solutions as well as to hydrogen ion in ordinary water. Futhermore, the glass-calomel pH assembly is useful for practical measurements of pD in heavy water. Several standard reference solutions for pD are needed, however, as the response of individual glass electrodes is not constant over the entire useful pD range. A suitable phosphate solution (pD 7.428 at 25 °C) composed of KD_2PO_4 and Na_2DPO_4 (each 0.025 molal) was established in earlier work. This reference has now been supplemented by two other useful buffer solutions, namely 0.05m KD_2 citrate (pD 4.293 at 25 °C) and a mixture of $NaDCO_3$ and Na_2CO_3 (each 0.025 molal) which has a pD of 10.736 at 25 °C. Values have been assigned at 10 temperatures from 5 to 50 °C. The conventional pD scale fixed by these three standards has been shown to have a satisfactory internal consistency.

11080. Pechukas, P., **Generalized Langevin equation of Mori and Kubo,** *Phys. Rev.* **164,** No. 1, 164-175 (Dec. 5, 1967).

Key words: Fluctuation-dissipation theorem; Langevin equation; stationary stochastic process.

We derive and discuss the generalized Langevin equation of Mori and Kubo for an arbitrary stationary stochastic process with continuously differentiable correlation function.

11081. Pecker, J. C., Thomas, R. N., **Saturation in Fraunhofer lines,** *Observatory Letter* **88,** No. 964, 115-117 (June 1968).

Key words: Absorption tube profiles; equivalent-width; line depth; line-profiles; non-LTE; optical thickness; saturation; source-function.

We take issue with an interpretation of line-profiles in terms of absorption tube profiles, as suggested in a Letter to the Editor of *Observatory* by Gussmann, and a critique of Pecker's saturation function to represent equivalent-width by Gussmann. We present a more correct interpretation in terms of a complete non-LTE formulation of the problem, introducing an "equivalent" or "effective" source-function.

11082. Peiser, H. S., **The relative magnitude of jump rates for point-defect paths between equivalent sites around a trap,** *J. Korean Phys. Soc.* **1,** No. 1, 5-8 (Mar. 1968).

Key words: Crystal relaxation; crystal symmetry; crystal trap; defect mobility crystal; point-defect; point group.

To a limited but significant extent, the relative magnitude of jump rates for point-defect paths between equivalent sites around a trap of non-cubic symmetry in crystals is governed by cross-over points of equivalent paths on the stereographic representation of the trap environment and by true intersections of paths caused by mirror planes of symmetry. The chief consequence is that in simple experiments the number of defect path types that cause observable internal-friction effects is greatly limited. Moreover, a closer estimate than is otherwise possible can be made of the number of distinct paths needed for complete or partial relaxations, associated with an external influence.

11083. Peterson, R. L., **Short-range magnetic order in a modified Weiss molecular-field theory,** *Phys. Rev.* **171,** No. 2, 586-590 (July 10, 1968).

Key words: Magnetism; molecular field theory; short-range order.

The Weiss molecular field theory (WMFT) of ferromagnetism, as commonly used, has the well-known defect that the short-range order and heat capacity vanish in zero applied field and temperatures above the Curie point. We here point out that the same use of the WMFT also gives an isentropic susceptibility equal to zero at all fields and temperatures, and two different results for the isothermal susceptibility, depending upon which of two direct methods of calculation are used. These difficulties are all traced to the use of the assumption that different spins are uncorrelated. We argue that this assumption is not consistent within the framework of the WMFT, and show that the molecular field assumption by itself provides a measure of the spin correlations. The assumption that only nearest neighbor spins are correlated is shown to be consistent at high temperature and to yield the correct high-temperature expression for the short-range order and heat capacity. Thus we argue that when correctly used, the WMFT does not possess the gross defects usually attributed to it. The discussion applies also to antiferromagnetism.

11084. Plummer, E. W., Gadzuk, J. W., Young, R. D., **Resonance tunneling of field emitted electrons through adsorbates on metal surfaces,** *Solid State Commun.* **7,** 487-491 (1969).

Key words: Adsorption; energy distribution; field emission; surface; tunneling resonance.

Tunneling resonance of field emitted electrons through the energy levels of single Zr atoms and χ nitrogen adsorbed on a tungsten surface has been observed. The enhanced tunneling probability through the Zr atoms on tungsten shows that the "atomic band" of Zr is shifted by $\Delta E \sim 1.0-1.5$ eV with a width $\Gamma \sim 1$ eV. The resonance in χ nitrogen demonstrates that this nitrogen complex is probably negatively ionized.

11085. Pong, W., **Photoemission from Al-Al_2O_3 films in the vacuum ultraviolet region,** *J. Appl. Phys.* **40,** 1733-1739 (1969).

Key words: Al_2O_3 films; electron attenuation length; electron mean free path; photoelectric effect; photoelectric threshold; thin films; vacuum ultraviolet.

Measurements of quantum yield of Al-Al_2O_3 films were made at photon energies between 7 and 22 eV. The photoelectric threshold for intrinsic photoemission from amorphous Al_2O_3 appeared to be about 8 eV. Approximately 1 eV was estimated for the electron affinity of Al_2O_3. The yield of anodic oxide film on aluminum at 10.2 eV decreased with increasing oxide thickness while the yield at 21.2 eV increased. The decrease in yield at 10.2 eV was attributed to photoelectrons originating from the aluminum film beneath the oxide layer. Attempts were made to study the escape probability function for electrons moving through the oxide into the vacuum. An attenuation length of about 129 Å for the photoelectrons in the oxide was obtained by using the exponential-function approximation. The maximum initial energy of the electrons was estimated to be 7.8 eV above the vacuum level. The electron mean free path for electron-phonon collisions in the oxide was estimated to be approximately 16 Å.

11086. Pool, K. H., Bates, R. G., **Thermodynamics of hydrochloric acid in 95 volume percent (92.41 mass percent) ethanol from e.m.f. measurements at 5 to 50 °C,** *J. Chem. Thermodynamics* **1,** 21-29 (1969).

Key words: Activity coefficients; emf measurements; enthalpy; entropy; ethanol-water solvents; hydrochloric acid; thermodynamics.

Electromotive-force measurements of cells of the type Pt;H_2, HCl(m) in EtOH-H_2O, AgCl;Ag at 10 temperatures from 5 to 50 °C have been used to derive (a) the standard emf of the cell in 92.41 wt. percent ethanol, (b) the activity coefficient of hydrochloric acid, (c) the relative partial molal enthalpy and heat capacity of HCl, and (d) the thermodynamic constants for the transfer of HCl from water to 92.41 wt. percent ethanol. The molality of the acid ranged from 0.0099 to 1.085 mol kg^{-1}. To obtain the standard emf it was necessary to correct for ion-pair formation and to use the extended terms of the Debye-Hückel theory. The ion-size parameter, chosen to minimize the sum of the squares of the deviations, varied only slightly with temperature, from 3.97 Å at 5 °C to 4.31 Å at 50 °C.

11087. Potzick, J., **Ac-dc regulator-modulator,** *Rev. Sci. Instr.* **39,** No. 8, 1219-1220 (Aug. 1968).

Key words: Feedback; modulator; regulator.

A general purpose regulator-modulator is described in which the gain of a d-c amplifier is determined by a control voltage derived through an external feedback loop.

11088. Powell, C. J., **Characteristic energy losses of 8-keV electrons in liquid Al, Bi, In, Ga, Hg, and Au,** *Phys. Rev.* **175,** No. 3, 972-982 (Nov. 15, 1968).

Key words; Aluminum; bismuth; electron energy loss; gallium; gold; indium; liquids; mercury; solids.

Characteristic loss spectra have been obtained in a reflection scattering geometry for liquid Al, Bi, In, Ga, Hg and Au and, in the case of Al, Bi and Au, for the same specimens in the solid phase. Peaks due to surface and volume plasmon excitation dominated the loss spectra for all elements except Au. The relative intensity of these peaks varied rapidly with scattering angle for the liquid and frozen specimens but there was little angular variation when Al, Bi, or Au was evaporated onto a frozen substrate of the same element. The Al plasmon losses varied with temperature and changed at the mp as would be expected from the known density variation. Changes in the Bi plasmon energy losses on melting and changes in other structure on melting have been interpreted in terms of band-structure changes. The peaks in the gold loss spectra appeared to become broader and less distinct on melting from which it was concluded that the Au excited states had shorter lifetimes with increased disorder. In general, however, the liquid and solid-state spectra of the same element were similar, thereby showing that for these materials there was not a large change in band structure on melting.

11089. Powell, C. J., **Interaction of electrons with solids,** Chapter 9.2 in *Atomic and Electron Physics, Atomic Interactions,* **Vol. 7,** *Methods of Experimental Physics,* B. Bederson, ed., Part B, pp. 275-305 (Academic Press Inc., New York, N.Y., 1968).

Key words: Cross-sections; elastic scattering; electron detectors; electron energy analyzers; electron guns; electron scattering; electron-solid interactions; experimental techniques; inelastic scattering; multiple scattering; secondary processes; specimen preparation.

A review is given of methods and techniques useful in experiments where electrons of energy between 0 and 100 keV interact with solids. A general discussion is given firstly of common experimental components and procedures: electron guns, energy analyzers, and electron detectors; specimen preparation; and experimental strategy. The interaction of electrons with solids is considered firstly by assuming that the solid can be represented as an assemblage of atoms, thereby simplifying the analysis. Elastic and inelastic scattering measurements are discussed, followed by a survey of methods useful in situations where multiple scattering occurs and where secondary or higher order electrons and photons are generated. Finally, the relevance of angular anisotropies in elastic and inelastic electron scattering by crystalline solids is described.

11090. Powell, R. L., Clark, A. F., Fickett, F. R., **Longitudinal magnetoresistance of pure copper,** (Proc. Conf. Electron Mean Free Paths in Metals, Zurich, Switzerland, Sept. 3-5, 1968), *Phys. kondens. Materie* 9, 104-112 (Lange and Springer, Berlin, West Germany, 1969).

Key words: Copper; electronic scattering; magnetoresistance.

Pippard suggested that the longitudinal magnetoresistance for metal crystals should give information about electronic scattering mechanisms on the Fermi surface. Therefore we have determined the magnetoresistance saturation ratio ($R\{B = \text{saturation}\}/R\{B=0\}$) for copper crystals of different orientations at varying temperatures in order to test several hypotheses concerning the anisotropy of mean-free-paths and the validity of diffusion or relaxation-time approximations. The temperature dependence of the saturation ratios along the [100] and [110] directions has been determined from 4 to 35 K. Near 35 K experimental ratios are well below theoretical values calculated using even wide (5 to 1) variations for the mean-free-path. As the temperature decreases from 35 K and the average scattering angle decreases, the ratio rises as would be expected from an approach to the diffusion approximation, but then decreases again as impurity scattering, which would be expected to be more isotropic, begins to dominate.

11091. Przybylowicz, E. P., Smith, G. W., Suddueth, J. E., Nargolwalla, S. S., **Activation analysis of halogens in photographic**

emulsions using a neutron generator, *Anal. Chem.* **41,** No. 6, 819-823 (May 1969).

Key words: Chloride; iodide; nondestructive neutron activation analysis; photographic emulsions; silver bromide; 2.8-MeV neutrons; 14.7-MeV neutrons.

A nondestructive neutron activation technique for the analysis of chloride and iodide in a silver bromide matrix is described. Chlorine was measured after activation with 14.7-MeV neutrons. The 3.1-MeV gamma rays from ^{37}S were measured without interference. Calibrations were carried out using photographic emulsions containing 10- to 200 milligrams of chlorine. The relative standard deviation of a single determination at the 10 milligram level is 5 percent; at the 200 milligram level it approaches 1 percent. Iodine was measured via ^{128}I produced by (n,γ) activation with 2.8-MeV neutrons. A straight line curve was established for 2- to 420 milligrams of iodine. The relative standard deviation of a single determination at these two levels was 20 and 1 percent respectively. The method offers an attractive alternate to existing chemical and instrumental methods for the determination of iodide and chloride in silver halide mixtures since it has the potential for providing rapid analysis with reasonably good precision. With an order of magnitude increase in neutron flux, the method would be unquestionably superior to other instrumental methods for the halides.

11092. Quindry, T. L., **Transmissibility measurements for the determination of structural damping,** (Proc. Vibrations Conf., Philadelphia, Pa., Mar. 30-Apr. 2, 1969), *Preprint* No. 69-VIBR-36, 7 pages (American Society of Mechanical Engineers, New York, N.Y., 1969).

Key words: Air; antiresonances; cantilever beam; damping; mass-loading; resonances; tip rotary inertia; transmissibility; vacuum.

A straightforward means of determining the damping coefficient of structural metals by the use of a mass-loaded cantilever beam is described. In order to determine the structural damping coefficient, δ, from the form $E^* = E(1 + j\delta)$, experimental data is normalized to fit the non-dimensional equations of transmissibility. Only the experimental values of frequency for the first and second resonance and of transmissibility for the first antiresonance and second resonance are needed to determine the structural damping coefficient. The boundary conditions account for the effects of mass-loading and tip rotary inertia. For the same alloys, root stress and temperature did not vary appreciably during the conditions of the test.

Good repeatability was obtained for tests in air and in vacuum from specimens of ZK60A T5 magnesium alloy and 2024 T4 aluminum alloy.

Advantages of mass-loading and obtaining the structural damping coefficient from transmissibility at the second resonance are cited.

11093. Radford, H. E., **Scanning microwave echo box spectrometer,** *Rev. Sci. Instr.* **39,** No. 11, 1687-1691 (Nov. 1968).

Key words: Cavity spectrometer; echo box; free radicals; hydroxyl radical; microwave absorption.

A resonant cavity microwave spectrometer for wavelengths between 3 and 30 cm, which uses radar echo boxes as absorption cells, is described. The minimum detectable absorption coefficient at 10 cm wavelength is 10^{-10} cm^{-1}, and this sensitivity is maintained during frequency scans by automatic feedback tuning of the echo box. The spectrometer is well suited to studies of gaseous chemical reactions, and some preliminary observations are reported, including the negative results of a search for the 10 cm spectrum of CH, and measurements of OH spectra at 4.7 and 6.0 GHz.

11094. Ray, C. D., Tsukishima, T., Hyland, R. N., McLane, C. K., Carpenter, R. J., **Analysis of a frequency-swept one-bit digital correlator,** *J. Appl. Phys.* **39,** No. 8, 3534-3542 (July 1968).

Key words: Correlator; cross-correlator; diffusion coefficient; digital correlator; frequency-swept; plasma.

An instrument for measuring the cross spectral density of two random variables which are correlated is described. It was constructed to study the relationship between electron density fluctuations and the ambipolar diffusion coefficient in a plasma. A stability in the zero correlation level of 10^{-3} is achieved by use of one-bit digital electronics in the multiplier and integrator. An analysis of the design and function of the instrument is given together with a discussion of possible instrumental errors and statistical uncertainties in the measurements.

11095. Rebbert, R. E., Ausloos, P., **The photolysis of methane at 584 Å,** *J. Am. Chem. Soc.* **90,** 7370-7371 (1968).

Key words: Charge transfer; ion-molecule reactions; methane; photolysis; rare gas.

The photolysis experiments described in this paper have been carried out with an enclosed helium resonance lamp. To our knowledge those are the first studies carried out with such a light source. The experimental results obtained at pressures varying from one to 15 torr are in general agreement with the published mass spectrometric data which are generally obtained around 10^{-5} torr.

11096. Risley, E. W., **Discontinuity capacitance of a coaxial line terminated in a circular waveguide,** *IEEE Trans. Microwave Theory Tech.* **MTT-17,** No. 2, 86-92 (Feb. 1969).

Key words: Discontinuity capacitance; open circuited coaxial line; Rayleigh-Ritz variational method; solid center conductor.

This calculation evaluates the discontinuity capacitance of a coaxial line terminated in a circular waveguide using the Rayleigh-Ritz variational technique. A 50 ohm, 3/4 inch, coaxial line termination with solid center conductor was fabricated with center and outer conductor dimensions of 0.32568 ± 0.00002 and 0.74995 ± 0.00002 inches respectively. The measured value of capacitance of this termination at 1000 Hz was 2.164×10^{-13} farads as compared with the calculated value of 2.177093×10^{-13} farads. Calculated values of capacitance for other line sizes were also compared with measured values and in each case the calculated value agreed with the measured value to within the experimental error of the measured value.

11097. Roach, F. E., **Diffuse galactic light,** Chapter in *Modern Astrophysics: A Memorial to Otto Struve,* M. Hack, ed., pp. 49-66 (Gordon and Breach, New York, N.Y., 1967).

Key words: Airglow continuum; diffuse starlight; galactic light; light; starlight.

The observational evidence for the existence of diffuse starlight scattered by interstellar dust is reviewed. The observational difficulty in the measurement lies in the fact that the so-called galactic light is a relatively faint component of the light of the night sky in competition with the zodiacal light, the integrated starlight and the airglow continuum. Recent observations made at Haleakala (Hawaii) indicate a galactic light with a dependence on galactic latitude in only partial agreement with a theoretical paper by Wang Shih-Ky.

11098. Roach, F. E., **The brightness of the zodiacal light at the ecliptic pole,** (Proc. Symp. Meteor Orbits and Dust, Cambridge, Mass., Aug. 9-19, 1965), *Smithsonian Contributions to Astrophysics,* F. L. Whipple, ed., **11,** 225-226 (Smithsonian

Institution Astrophysics Observatory, Cambridge, Mass., 1967).

Key words: Photometry; zodiacal light.

A review of current photometric studies of the zodiacal light indicates that it has a brightness at the pole of the ecliptic of 110 S10(vis) units compared with 250 in the plane of the ecliptic at an elongation of 90°. The ratio of brightness (250/110 = 2.3) is a measure of the concentration of the zodiacal cloud toward the ecliptic.

11099. Robbins, C. R., **Growth of strontium titanate from a silica flux,** *J. Crystal Growth* **2,** 402-404 (1968).

Key words: Flux growth; high temperature microscopy; silica flux; single crystals; strontium titanate.

A survey of selected compositions in the ternary system $SrO-TiO_2-SiO_2$ by high-temperature microscopy has shown that single crystals of $SrTiO_3$ may be grown from a silica flux. Crystals up to 2.5 mm in longest dimension were obtained in a small scale experiment by slow cooling of a 20 g melt of mole ratio 1 $SrTiO_3$:1 SiO_2. The crystals are clear, colorless to pale brown, of good optical quality, free from inclusions and show no evidence of solid solution by x-ray powder diffractometry.

11100. Romanoff, M., **Performance of ductile-iron pipe in soils,** *J. Am. Water Works Assoc.* **60,** No. 6, 645-655 (June 1968).

Key words: Cast iron; corrosion; ductile iron; exposure sites; ferrous metals; gray iron; pipe; pipelines; underground; soil corrosion.

This is a progress report on the behavior of specimens of ductile cast-iron pipe after exposures for 1, 2, 4 and 8 years at five National Bureau of Standards soil corrosion test sites. It can be concluded from the data that ductile cast-iron and gray cast-iron corrode at nearly the same rate in a given soil environment, and that the pattern of corrosion and nature of the graphitic corrosion products are also similar for the two materials in a given soil.

11101. Rossmassler, S. A., **Modification of dissemination channels for scientific information,** *J. Chem. Doc.* **9,** No. 1, 17-19 (Feb. 1969).

Key words: Abstract journal; evaluation; dissemination; information analysis; redesign; scientific information; technical literature.

Traditional channels for the dissemination of scientific information are based on primary publication in a scientific journal, with reader guidance provided by an abstract journal. These channels are designed primarily to meet the author's requirement and are document-oriented. The present growth of scientific information calls for a redesign of the technical literature. It is proposed that the single piece of scientific information be recognized as the unit of flow into the distribution system. The resulting need for organized efforts for selection and evaluation of information, and increased emphasis on users' requirements lead to modification of dissemination channels. Possible changes in present publication practices are considered.

11102. Rothwell, G. J., **The performance concept: a basis for standards development,** *ASTME Vectors* **1969/2,** 23-25 (Mar.-Apr. 1969).

Key words: Engineering standards; performance concept; performance standards.

Technological measurements and standards are use-related and at the interface between science and its application in industry and government. They extend the principles of good measurement to the engineering world and to the complex needs of today's society.

But it is increasingly important that such measurements and standards do not hamper the introduction of new technologies or innovations for accomplishing society's objectives. One way to avoid such restrictions is suggested by the concept of using performance requirements as the basis for standards. This concept includes a concern for subjective factors which of necessity enter measurement problems as soon as man becomes part of the system to be measured.

11103. Rush, J. J., Melveger, A. J., Farrar, T. C., Tsang, T., **Laser-Raman spectra and hindered rotation in the phosphonium halides,** *Chem. Phys. Letters* **2,** No. 8, 621-624 (1968).

Key words: Crystal structure; force field; hindered rotation; laser; phosphonium halides; Raman spectra; torsional oscillation; vibration.

Laser Raman spectra have been measured for PH_4Cl, PH_4Br and PH_4I. Intense peaks in all the halide spectra are assigned to torsional (E_g) oscillations and to the internal vibrations of the PH_4^+ ions. Barriers to PH_4^+ rotation are calculated and discussed in comparison with recent spectroscopic and structural results.

11104. Ryan, J. V., **Flammable Fabrics Act and its implementation,** *Mod. Textiles Mag.* **L,** No. 3, 67-70 (Mar. 1969).

Key words: Fabrics; flammability; Flammable Fabrics Act; interior furnishings; National Advisory Committee; textiles; textile technology; wearing apparel.

The provisions of the Amendments to the Flammable Fabrics Act are reviewed against the background of the original Act plus experiences with its effectiveness. Cooperation with the accident investigation efforts of the Public Health Service is described. Acquisition of data from additional sources has been somewhat successful.

The Department's procedures for rulemaking involve several steps with opportunity for comment from interested parties at two different times, followed by consultation with the National Advisory Committee for the Flammable Fabrics Act.

A general program approach is described, but the level of funding for the current fiscal year will place serious limitations on the ability to implement the program fully.

11105. Ryan, J. V., **The Flammable Fabrics Act and its implementation,** *Proc. Second Annual Meeting Information Council on Fabric Flammability, New York, N.Y., Dec. 3, 1968,* pp. 231-237 (Information Council on Fabric Flammability, New York, N.Y., 1968).

Key words: Carpets; fabrics; Flammable Fabrics Act; National Advisory Committee; procedures; regulations; textiles; wearing apparel.

The 1967 Amendments to the Flammable Fabrics Act delegated authority for establishment of regulations, research, investigations and test method development, and called for a National Advisory Committee with which the Secretary of Commerce must consult.

The National Bureau of Standards has been coordinating with Public Health Service in studying burn cases, and has established a Fabric Flammability Section to carry out the research responsibilities, the coordination, data analysis, and the formulation or recommendations for new or amended standards and regulations. Research will start with basic consideration of what happens in fires that represent hazards to life and property. Data will be considered from any competent source, in or out of government. Consumers Union has provided data on carpets and blankets. The Department has published Procedures for developing standards, and findings that there may be need for standards for wearing apparel and for rugs and carpets. Announcement of the membership of the National Advisory Committee is expected in the near future.

11106. Sanderson, B. T., Romanoff, M., **Performance of commercially pure titanium in corrosive soils,** *Mater. Production* **8,** No. 4, 29-32 (Apr. 1969).

Key words: Corrosion; exposure sites; pipe; soil corrosion; steel; titanium; underground.

This is a progress report on the behavior of specimens of titanium tubing with welded seams after exposure in the soils at six National Bureau of Standards corrosion test sites for exposures up to 8 years. The data show that the titanium tubing as well as the weld and heat affected zones are unaffected by corrosion with respect to pitting or metal attack in any of the soil environments to which they were exposed. Weight losses on the specimens were negligible in all soils. Data for carbon steel pipe specimens which were used as a reference material to determine the corrosiveness of the soils are included.

11107. Santoro, A., Mighell, A. D., Zocchi, M., Reimann, C. W., **The crystal and molecular structure of hexakis (imidazole)Ni (II) nitrate,** *Acta Cryst.* **B25,** No. 3, 842-847 (Apr. 1969).

Key words: Imidazole; ligand; octahedral coordination, complex; trigonal symmetry; x-ray structure determination.

The crystal and molecular structure of hexakis(imidazole) nickel(II)nitrate, $(C_3H_4N_2)_6Ni(NO_3)_2$, was determined by single-crystal x-ray diffraction techniques. This compound crystallizes in the trigonal system, space group $R\bar{3}$. The lattice parameters (hexagonal axes) are $a = 12.353 \pm 0.001$, $c = 14.803 \pm 0.002$ A, $Z = 3$, $\rho_o = 1.51$ g cm^{-3}, $\rho_c = 1.506$ g cm^{-3}. Three dimensional data were used (905 reflections) and the structure solved by an analysis of the Patterson map. The complex cation $(C_3H_4N_2)_6Ni^{++}$ has $\bar{3}$ point symmetry with the nickel atom at the center of a slightly compressed octahedron of nitrogen atom. The imidazole rings are planar to within experimental error. The final refinement by a three-dimensional least-squares analysis resulted in a R value 7.1 percent.

11108. Santoro, A., Weir, C. E., Block, S., Piermarini, G. J., **Absorption corrections in complex cases. Application to single crystal diffraction studies at high pressure,** *J. Appl. Cryst.* **1,** Part 2, 101-107 (June 1968).

Key words: Absorption correction; bromine; crystal structure; high-pressure; x-ray diffraction.

A method is described for evaluating the absorption corrections in complex cases in which objects other than the crystal itself take part in the absorption. The method has been applied to the high-pressure cell developed in this laboratory, and it has been tested on a set of intensities obtained from a single crystal of bromine grown and maintained under 10 kbar pressure.

11109. Sarachman, T. N., **Microwave spectrum of** ***cis*****-2-butene,** *J Chem. Phys.* **49,** No. 7, 3146-3149 (Oct. 1, 1968).

Key words: Barrier; *cis*-2-butene; dipole moment; internal rotation; microwave spectrum; molecular structure.

The microwave spectrum of the *cis*-2-butene molecule has been studied between 20 and 40 Gc/sec. Analysis of internal rotation splittings yields an effective three-fold barrier of .73 kcal/mol or 26 cm^{-1}. The principal moments of inertia of the normal isotopic species are 31.479, 98.370, and 123.659 amu Å^2. The electric dipole moment is $.25_7$ and lies along the b axis of the molecule.

11110. Saunders, J. B., Bruening, R. J., **A new interferometric test and its application to the 84-in. reflecting telescope at Kitt Peak National Observatory,** *Astron. J.* **73,** No. 6, 415-531 (Aug. 1968).

Key words: Aberration of telescopes; interferometer; shearing interferometer; telescopes; wavefront shearing interferometer.

The 84 inch aperture, Cassegrainian type telescope at Kitt Peak National Observatory was tested with a wavefront shearing interferometer. This test provided the optical path difference between 538 uniformly spaced rays in the annular beam of light transmitted by the telescope. Independent tests were made from photographs taken on each of two consecutive nights. The following results were obtained from this test: (a) the coordinates of the points of incidence of each of the 538 rays on the focal plane (a spot diagram); (b) a measure of primary astigmatism; and (c) the deviation of the wavefront, at 538 uniformly spaced points, from a sphere that is centered on the ideal image point.

A description of the mathematical operations is given with the results. The results show a measurable change in the waveform during the test periods (approximately 30 minutes) each night and a larger difference from one night to the next.

11111. Saylor, C. P., **The freezing staircase method,** Chapter 11 in *Purification of Inorganic and Organic Materials,* M. Zief, ed., pp. 125-138 (Marcel Dekker Inc., New York, N.Y., 1969).

Key words: Crystallization; entrapment; impurity; phase equilibrium; purification; purity; solid solution.

In the freezing staircase method of purification, frozen portions of the material being purified are attached to the walls of the vessel. They move slowly with the rotating apparatus, transporting matter in that direction. An equal mass of liquid flows in the opposite direction. The solid portions are maintained in a crystalline state by stationary coolers outside the containers. Since the growing front and the melting surfaces of each solid portion remain stationary, the solid is caused to grow on one side and melt on the other until, under good conditions, it becomes monocrystalline. By this means there is a close approach to theoretical distribution coefficient of impurity between the liquid and solid phases except at locations in the apparatus where the concentration of solid insoluble impurities is at a high level (>5%). During the greater part of any run under good conditions, there is no spontaneous nucleation. Encapsulation and entrapment are nearly or entirely eliminated. There is no back mixing of rejected impurities. Purification factors can easily be achieved in each stage which are clearly in excess of one thousand.

11112. Scala, A. A., Ausloos, P., **Gas-phase photolysis and radiolysis of cyclopropane,** *J. Chem. Phys.* **49,** No. 5, 2282-2290 (Sept. 1, 1968).

Key words: Cyclopropane; free radical reactions; ion-molecule reactions; photolysis; radiolysis.

The gas phase photolysis of c-C_3H_6-O_2, C_3H_6-NO and c-C_3D_6-H_2S mixtures has been investigated at 1470 Å (8.4 eV), 1236 Å (10 eV) and at 1048-67 Å (11.6-11.8 eV), that is at photon energies below and above the ionization energy of cyclopropane (I.E. = 10.06 eV). Examination of the products formed in the gas phase experiments at 1470 and 1236 Å as well as of those formed in a few solid phase photolysis experiments indicate that the major primary act of the neutral excited cyclopropane molecule can be written as follows: $c\text{-}C_3H_6 + h\nu \rightarrow CH_2CH_2CH_2^*$. The highly excited trimethylene decomposes mainly to form CH_2 and C_2H_4. There is, however, also evidence for rearrangement $CH_2CH_2CH_2^* \rightarrow CH_3CHCH_2^*$ which, at low densities, is always followed by fragmentation of CH_3CHCH_2.

11113. Schafer, G. E., **Precision microwave measurements – today and tomorrow,** *Microwave J.* **12,** No. 6, 25-28 (June 1969).

Key words: Measurements; microwave.

This is an invited guest editorial. The request called for a review of the state-of-the-art of measurements and some speculation on the trends of standards and measurements. This is done in the paper by examples only, since an in-depth review would greatly exceed the two or three printed pages allowed by the Microwave Journal.

11114. Scharf, K., **Steady-state response of silicon radiation detectors to x and gamma rays,** *Proc. Symp. Physics and Nondestructive Testing, ITT Research Institute, Chicago, Ill., Sept. 27-30, 1966,* **1,** 235-298 (Air Force Materials Laboratory, Wright-Patterson Air Force Base, Ohio, 1968).

> Key words: Dosimetry; gamma rays; photodiodes; photovoltaic effects; radiation detection; radiation detectors; semiconducting devices; silicon; x rays.

A review is given of investigations of the steady-state response of silicon radiation detectors to x and gamma rays which were carried out in the Radiation Physics Division of the National Bureau of Standards. Theoretical relations between photocurrents generated in such detectors by x and gamma rays and exposure rate and quality of radiation are explained. Measurements of the dependence of the generated photocurrent on exposure rate, quality of radiation, voltage applied, and detector temperature carried out on different types of detectors are presented, and different modes of operation of silicon radiation detectors are discussed. By using a special electrical compensation method, exposure rates were measured ranging from 100 mR/hr of ^{137}Cs gamma rays to 10^5 R/hr of 30-kV x rays.

11115. Scheer, M. D., Fine, J., **The reaction of carbon monoxide with a tantalum surface heated above 2000 °K,** *Surface Sci.* **12,** No. 1, 102-107 (Sept. 1968).

> Key words: Activation energy; carbon monoxide; high temperature; mass spectrometry; surface reaction; tantalum.

The high temperature surface interaction between carbon monoxide and tantalum has been studied with mass spectrometric detection of the gaseous products. It has been shown that carbon monoxide is reduced by tantalum to form TaO above 2200 °K. This process is first order in its dependence on carbon monoxide pressure and proceeds with an activation energy of 5.1 eV.

11116. Scheer, M. D., Klein, R., **Low-temperature oxygen atom addition to olefins. III. Transition state and the reaction with** *cis-* **and** *trans-***2-butenes,** *J. Phys. Chem.* **73,** No. 3, 597-601 (Mar. 1969).

> Key words: Chemistry; low temperature; olefins; oxygen atom; 2-butene.

The reaction of ground state oxygen atoms O(^{3}P), with either *cis* or *trans* 2 butene at cryogenic temperatures produces *cis* and *trans* 2,3 epoxybutane, 2 butanone, and isobutyraldehyde. Product ratios are different for the two butenes. Two precursor states, one leading to the *trans* epoxide and 2 butanone, and the other to the *cis* epoxide and isobutyraldehyde, are implied by the constancy of the ratios *trans* 2,3 epoxybutane/2 butanone and *cis* 2,3 epoxybutane/isobutyraldehyde. A new transition state for the O atom-olefin reaction is proposed. A prediction based on the new transition state for the O atom reaction with 2 methyl 2 butene was consistent with the experimental finding.

11117. Schmidt, L. B., Case, W. E., Harrington, R. D., **Surface dependence of ferrimagnetic resonance fields in polycrystalline NiAl ferrite,** *Proc. IEEE* **56,** No. 7, 1236-1237 (July 1968).

> Key words: Ferrite; ferrimagnetic resonance; ferrimagnetic resonance surface effect; nickel aluminum ferrite.

Data obtained at 1107 MHz demonstrates that the ferrimagnetic resonance field of polycrystalline Nickel Aluminum Ferrite depends upon the surface finish of the disk samples used in the measurement. Verification of this surface dependence at 3140 MHz is also reported.

11118. Schweitzer, W. G., Jr., **Saturated absorption by neon inside a 6328 Å laser with a mixture of neon isotopes in its gain tube,** *Appl. Phys. Letters* **13,** No. 11, 367-368 (Dec. 1, 1968).

> Key words: Laser; neon; isotope shift; saturated absorption; wavelength standard.

In a saturated absorption experiment with neon in a 6328 Å He-Ne laser one can select a combination of isotopes of neon in the gain tube and the proper isotope in the loss tube so as to bring the maximum of the gain curve to the same frequency as that of the saturated absorption peak.

11119. Sengers, J. V., **Transport properties of compressed gases,** Chapter in *Recent Advances in Engineering Science,* A. C. Eringen, ed., III, 153-196 (Gordon and Breach Science Publ. Inc., New York, N.Y., 1968).

> Key words: Compressed gases; thermal conductivity; transport properties; viscosity.

This paper reviews the experimental information on the viscosity and thermal conductivity of compressed one-component gases. The common features in the pressure and density dependence of these transport coefficients observed for various simple gases are summarized. An assessment is made of some methods used to predict the transport coefficients of a compressed gas and the relation between experiment and theory is discussed. A survey is included of the behavior of viscosity and thermal conductivity in the critical region and of the anomalous behavior of the dimensionless Rayleigh and Prandtl number, frequently encountered in the description of certain heat transfer processes. A new method to study transport processes by observing the spectrum of scattered light is discussed and some applications are indicated.

11120. Shah, J. A., Huber, M. G., Danos, M., **Separability of the nuclear residual two-body interaction,** *Physics Letters* **28B,** No. 6, 381-383 (Jan. 6, 1969).

> Key words: Effective forces; nuclear forces; nuclear shell model; residual forces; separable forces.

The separability of a residual two-body interaction with finite range has been studied by calculating the giant resonance states of O^{16}. From the comparison of the effect of an appropriate separable force with the results of an exact calculation it seems that the residual nucleon-nucleon interaction can be represented quite well by a simple separable force which corresponds to the exchange of just one value of momentum between the two particles.

11121. Sher, A. H., **Lithium-ion drift mobility in germanium,** *J. Appl. Phys.* **40,** No. 6, 2600-2607 (May 1969).

> Key words: Germanium; lithium ion mobility; radiation detectors.

The mobility of lithium in germanium has been determined at several temperatures between 23.8 and 61.2 °C by measuring the change of the capacitance with time of a reverse-biased p-i-n diode. The mobilities of lithium thus obtained (at the specified temperatures) were: 3.04×10^{-10} cm^2/V-s (23.8 °C), 5.30×10^{-10} cm^2/V-s (36.2 °C), 7.96×10^{-10} cm^2/V-s (46.2 °C), and 16.86×10^{-10} cm^2/V-s (61.2 °C). These values are higher than those which are obtained by the extrapolation of the results of others determined at higher temperatures into this temperature range. The results also suggest that at least three distinct field configurations exist during the early stages of the lithium drifting process rather than the two normally considered.

11122. Shirk, J. S., Bass, A. M., **Matrix-isolation spectra of discharge "sputtered" metals,** *J. Chem. Phys.* **49,** No. 11, 5156-5160 (Dec. 1, 1968).

Key words: Atomic spectra; high temperature materials; low temperature; matrix isolation; sputtering; ultraviolet spectroscopy.

Atomic Cu, Ag, Cd and Fe are produced by bombarding the appropriate metal with positive ions from a microwave discharge. The process is similar to sputtering. The metal atoms are trapped in an inert gas matrix on a cold window and their UV spectra observed. This is a new method for isolating high melting materials in a matrix for spectroscopic study.

11123. Shirley, J. H., **Dynamics of a simple maser model,** *Am. J. Phys.* **36,** Part 1, No. 11, 949-963 (Nov. 1968).

Key words: Laser dynamics; maser amplifier; maser dynamics.

A simple maser model consisting of a single mode field coupled to N identical two-level atoms is presented. The assumption of negligible statistical correlation between the atoms and the field permits the Heisenberg equations of motion to be replaced by a self-consistent set of ordinary nonlinear differential equations. Relaxation terms and an energy source are introduced phenomenologically. The resulting equations exhibit a threshold, stable and unstable steady states, and relaxation oscillations. The dynamic equations for the hydrogen maser and the rate equations of laser theory are derived as special cases. Also discussed are the maser amplifier, locking of a maser to an external signal and the effects of cavity thermal noise.

11124. Shives, T. R., Bennett, J. A., **The effect of environment on the fatigue properties of selected engineering alloys,** *J. Mater.* **3,** No. 3, 695-715 (1968).

Key words: Crack initiation; engineering alloys; environment; fatigue; humidity; oxygen.

Rotating beam fatigue tests were conducted in controlled environments on specimens of free cutting brass, titanium alloy Ti-4Al-4Mn, magnesium alloy AZ61A, and AISI 4340 steel. The fatigue strengths of all the alloys were lower in a moist atmosphere than in a dry one, although the difference was small for the brass specimens. The effect of oxygen on the fatigue behavior of the titanium alloy and a vacuum-melted 4340 steel was investigated by conducting tests both in air and in an inert gas; the influence of oxygen was found to depend on whether or not moisture was present. In many of the vacuum-melted steel specimens the fatigue crack started below the surface, and the performance of these individual specimens was related to the size of the inclusion at the origin of the crack. A coating of dodecyl alcohol had a beneficial effect on the two materials (magnesium alloy and steel) on which its influence was investigated. An interesting tarnishing effect was observed on the fatigue portion of the magnesium alloy fracture surfaces.

11125. Shumaker, J. B., Jr., **Franck-Condon factors for high rotational levels of nitrogen,** *J. Quant. Spectry. Radiative Transfer* **9,** 153-156 (1969).

Key words: Band strength; Franck-Condon factor; nitrogen; rotation-vibration interactions.

Franck-Condon factors and band strengths of some strong bands of the first negative, first positive, and second positive systems of nitrogen are calculated in the Morse potential approximation and are shown to exhibit little dependence upon rotational level up to rotational quantum number 100.

11126. Shumaker, J. B., Jr., Popenoe, C. H., **Experimental test of H_β Stark-broadening theory at high electron densities,** *Phys. Rev. Letters* **21,** No. 15, 1046-1048 (Oct. 7, 1968).

Key words: H_β profiles; plasma arcs; Stark broadening; temperature measurement.

H_β spectral line profiles produced in atmospheric pressure high current arc experiments at the Fowler-Milne normal electron density are compared with theory and found to agree within the approximately 10 percent uncertainty of the theory under these conditions.

11127. Sieck, L. W., **Continuum emission from xenon in the vapor phase induced by absorption of 1470 Å radiation,** *J. Phys. Chem.* **72,** No. 9, 3129-3133 (Sept. 1968).

Key words: Emission spectroscopy; energy level of diatomic molecules; energy transfer; gas phase kinetics; rare gas photosensitization; vacuum ultraviolet photochemistry.

When xenon is exposed to a source of its own lowest energy resonance radiation (1470 Å) in the vapor phase a symmetric continuum is observed in emission which exhibits a maximum at approximately 1715 Å. The addition of excess krypton to low pressures of xenon increases the continuum intensity substantially, and that "quenching" effects of other additives which are transparent to the resonance radiation are also reported. The kinetic data are generally, although not uniquely, consistent with the mechanism proposed by others to describe the origin of a molecular emission found in the afterglow of a pulsed discharge through krypton. In spite of the apparent kinetic agreement, however, marked dissimilarities exist in the contours of the respective bands and the positions of the continua when compared to the wavelength (energy) of the appropriate ${}^3P_1 \leftrightarrow {}^1S_0$ resonance transition.

11128. Sieck, L. W., **Xenon-photosensitized decomposition of methane at 1470 Å,** *J. Chem. Phys.* **50,** No. 4, 1748-1753 (Feb. 15, 1969).

Key words: Energy transfer; hydrocarbons; photochemistry; quantum yields; rare gas levels; (vacuum ultraviolet) sensitized decomposition.

The xenon sensitized decomposition of methane and methane-ethylene mixtures has been investigated in the vapor phase at 1470 Å.

Quantum yield determinations and analyses of the isotopic composition of the hydrogens and ethanes obtained from CH_4-CD_4 (1:1) mixtures under various conditions indicate that sensitization occurs by at least two concurrent mechanisms. The role of internal photolysis by resonating 1470 Å radiation was found to be negligible in all mixtures, and the existence of XeH as an important intermediate was inferred by chemical methods.

11129. Simmons, J. A., Coriell, S. R., **Solution of the Stefan problem for whisker evaporation,** *J. Appl. Phys.* **39,** No. 7, 3459-3463 (June 1968).

Key words: Mean adatom stay time; moving boundary; Stefan problem; surface diffusion; surface diffusion constant; whisker; whisker evaporation.

The moving boundary problem for whisker evaporation is solved numerically, using techniques previously developed for whisker growth. Curves of whisker length as a function of time are calculated for several values of the evaporation parameter. The possibility of determining the surface diffusion constant and the mean adatom stay time from whisker experiments is discussed.

11130. Simmons, J. D., Bass, A. M., Tilford, S. G., **The fourth positive system of carbon monoxide observed in absorption at high resolution in the vacuum ultraviolet region,** *Astrophys. J.* **155,** 345-358 (Jan. 1969).

Key words: Carbon monoxide; diatomic spectrum; molecular constants; perturbations; rotational analysis; vacuum ultraviolet region.

The absorption spectrum of the fourth positive system ($A^1\Pi - X^1\Sigma^+$) of carbon monoxide has been observed at high resolution in the region 1550-1060 Å. The rotational and vibration structure of 21 bands has been analyzed, viz the $v''=0$ progression for $v'=0$-18, 20 and the (0-1) band.

A detailed assignment of the numerous perturbation in $A^1\Pi$ state is given. Most of these perturbations can easily be assigned to the five known states in the region of the $A^1\Pi$ state. However a perturbation at low J-values in the (6-0) A-X band suggests the presence of another state in this region which has not as yet been observed directly.

11131. Smith, E. W., Hooper, C. F., Jr., **Comments on ion microfield distributions as used in plasma line broadening theories,** *J. Quant. Spectry. Radiative Transfer* **8,** No. 9, 1617-1619 (Sept. 1968).

Key words: Asymptotic wings; ion microfield; line center; line shape; transition region.

It is shown that the use of an extended ion microfield function gives rise to improved line shapes in the transition region between the line center and the asymptotic wings.

11132. Smith, S. J., **Photodetachment,** Chapter in *Methods in Experimental Physics,* **Vol. 7,** *Atomic and Electron Physics,* B. Bederson and W. L. Fite, eds., pp. 179-208 (Academic Press Inc., New York, N.Y., 1968).

Key words: Crossed beam method; drift tube experiments; I^-; negative ion; photodetachment; radiative attachment experiments.

11133. Smith, R. V., **Current developments in cryomedicine,** *Cryogenics* **9,** No. 2, 84-89 (Apr. 1969).

Key words: Cryobiology; cryomedicine; cryopreservation; cryoprotectants; cryosurgery; freezing; thawing.

The paper reviews current developments in the field by summarizing papers presented in the Fifth Annual Meeting of the Society for Cryobiology. Cryomedicine is divided into two areas for the purpose of discussion; cryosurgery and cryopreservation of biological material for clinical use.

11134. Smith, R. V., **Review of heat transfer to helium I,** *Cryogenics* **9,** No. 1, 11-19 (Feb. 1969).

Key words: Boiling; convection; critical; heat transfer; helium I; supercritical.

This paper reviews heat transfer to helium I. Recommendations are made for expressions to be used in design studies and for further work required to produce needed information.

11135. Smith, R. V., **Review of heat transfer to helium I,** *Proc. 1968 Summer Study on Superconducting Devices and Accelerators, Brookhaven National Laboratory, Upton, N.Y., June 10-July 19, 1968,* Part I, BNL 50155 (C-55), pp. 249-292 (Clearinghouse for Federal Scientific and Technical Information, Springfield, Va., Apr. 1969, $3.00).

Key words: Boiling; convection; critical; heat transfer; helium I; supercritical.

This paper reviews heat transfer to Helium I. The data were collected, complied, and the results discussed. Recommendations are made for expressions for use in design studies and for further work required to produce needed information.

11136. Steel, M. N., **Production of synthetic food materials: A statistical survey,** *Proc. Second Intern. Conf. Women Engineers and Scientists,* 30 pages (Women's Engineering Society, London, England, 1968).

Key words: Amino acids; food additives; food problem; production of synthetic food; synthetic food materials; urea; yeast.

This paper summarizes statistics on the production, sale, and value of synthetic vitamins, flavors, and amino acids in the United States from 1945 to 1965 and discusses the observed trends. In absence of statistics on the production in other countries, U.S. import statistics and information from industrial journals are examined for indications regarding quantities manufactured in other countries. U.S. shipment statistics are given for yeasts and are evaluated as a measure of the quantities being made. Production statistics for feed grade synthetic urea are also presented. The foregoing data are discussed in relation to the potential roles of synthetic and biosynthetic materials in meeting the world food deficit.

11137. Steiner, B., **The cross section for the photodetachment of electrons from I^-,** *Phys. Rev.* **173,** No. 1, 136-142 (Sept. 5, 1968).

Key words: Absolute cross section; iodine; negative ions; photodetachment.

The cross section for photodetachment of I^- at 347 nm, 0.5 eV above threshold, has been determined to be $2.9 \pm 0.5 \times 10^{17}$ cm². This value has been obtained in a crossed beam experiment by comparison with photodetachment from H^- at 993 nm, 0.5 eV above its threshold. The present determination permits placement of the previously determined relative cross section curve for the first electron volt above threshold on an absolute scale. The entire experimental curve is compared with the recent calculation of Robinson and Geltman. Although the shapes of the two curves are very similar, the new experimental cross section exceeds the calculation by a factor of two.

11138. Steiner, B., **Photodetachment of electrons from SH^-,** *J. Chem. Phys.* **49,** No. 11, 5097-5104 (Dec. 1, 1968).

Key words: Electron affinity; free radical; negative ions; photodetachment; SH.

The cross section for photodetachment of electrons from SH^- for the first 0.75 eV above threshold ($\lambda = 534.7$ to 403.0 nm) has been measured in a crossed beam experiment. The cross section rises rapidly in the first 0.15 eV ($\Delta\lambda = 35$ nm) to the value 1.9×10^{-17} cm² determined with a total uncertainty of $\pm 0.4 \times 10^{-17}$ cm² given by the square root of the sum of the squares of the maximum observed deviation and the allowances for various systematic factors; over the rest of the observed range it is constant. The detailed shape of the cross section vs. λ curve has been employed to derive the SH^- structural parameters (and their upper limits of uncertainty), which are indistinguishable from those of the neutral free radical: $R = 0.135 \pm 0.002$ nm, $\omega_e = 2700 \pm 290$ cm⁻¹, and $B_e = 9.46 \pm 0.32$ cm⁻¹. The electron affinity is identified with the observed photodetachment threshold, 2.319 ± 0.010 eV. These results are in general agreement with the recent calculations of Cade. Evidence is presented for the importance of inclusion of long range forces in dealing with the threshold behavior of photodetachment from heteronuclear diatomic negative ions.

11139. Stephens, R. E., Sutton, L. E., **Diffraction image of a point in the focal plane and several out-of-focus planes,** *J. Opt. Soc. Am.* **58,** No. 7, 1001-1002 (July 1968).

Key words: Diffraction image; image evaluation; lens analysis.

For the case of an aberration-free lens system with circular aperture, a table is presented which gives the fraction of maximum irradiance in the diffraction image of a point. The columns of the table correspond to variations in location of the focal plane; the rows to variations in the distance from the center of a diffraction pattern. These values were obtained, to an accuracy of five decimal places, through Gaussian integration of the required Bessel function expressions, the calculations being performed on a digital computer.

11140. Stevens, M. E., **Automatic analysis,** *Encyclopedia of Library and Information Science,* A. Kent and H. Lancour, eds., **2,** 144-184 (Marcel Dekker Inc., New York, N.Y., 1969).

Key words: Automatic character recognition; automatic classification; automatic content analysis; automatic indexing; automatic pattern recognition; key word indexing; linguistic data processing; question-answering; statistical association.

Progress in techniques and applications of automatic analysis are discussed in terms of library and information science interests. Topics discussed include automatic pattern recognition, machine indexing by extraction of key words, automatic indexing and classification, statistical association techniques, linguistic data processing, automatic content analysis and question-answering systems.

11141. Stevens, M. E., **Progress and prospects in mechanized indexing,** (Proc. Symp. on Mechanized Abstracting and Indexing, Moscow, U.S.S.R., Sept. 28-Oct. 1, 1966), *UNESCO/NS/209,* 51 pages (United Nations Educational Scientific and Cultural Organization, Paris, France, Apr. 1967).

Key words: Automatic classification; automatic indexing; indexer inconsistency; mechanized indexing; selective dissemination systems.

Recent progress and problems in mechanized indexing, both for machine-compiled and machine-generated indexes, are reviewed. Results of automatic indexing and classification experiments reported after issuance of the NBS State-of-the-Art Report are briefly reviewed. It is concluded that the progress and prospects of automatic indexing are provocative because of practical and theoretical accomplishments that have been demonstrated and challenging because much remains to be done.

11142. Stevens, M. E., **Selected pattern recognition projects in Europe,** *Pattern Recognition* **1,** No. 2, 103-118 (Nov. 1968).

Key words: Optical character; pattern recognition; recognition; research; speaker identification; speech recognition; standardized fonts; U.S.S.R.; Western Europe.

In August-September, 1966, a survey of selected non-numeric data processing projects in Western Europe was conducted. Some of the projects active in various areas of pattern recognition research and development that were visited are discussed. In addition, details are given of an operational character recognition system in the U.S.S.R.

11143. Steward, W. G., Smith, R. V., Brennan, J. A., **Cooldown time for simple cryogenic pipelines,** (Proc. Tenth Midwestern Mechanics Conf., Colorado State University, Fort Collins, Colo., Aug. 21-23, 1967), Chapter in *Developments in Mechanics* **4,** 1513-1525 (Johnson Publ. Co., Boulder, Colo., 1968).

Key words: Chilldown, cooldown time; cryogenic fluids; transfer lines.

An uncooled pipeline which is used to transfer a cryogenic fluid from one point to another, must ordinarily go through a period of cooling down from ambient temperature to near the liquid boiling temperature. During most of this period the liquid boils and the pipe delivers only warm gas. Some effective methods of estimating this cooldown time have been proposed but they are all laborious. This paper offers a quick method by which cooldown time for a simple system can be calculated from a dimensionless parameter read from a graph. To use the method it is necessary to know the fluid and pipe enthalpy, density, and velocity of sound in the warm gas. The idealized model and closed form solution are described, and comparison with experimental results is shown.

11144. Stiehler, R. D., Parks, E. J., Linnig, F. J., **Stiffening of elastomers by organic fillers,** *Appl. Poly. Symp.* No. 7, 143-153 (1968).

Key words: Anisotropic; beta-naphthyl group; block polymers; bonds; crystallization; elastomers; expansivity; forces; phenyl-beta-naphthylamine; stiffening; vulcanization; x-ray diffraction.

Elastomers can be stiffened in various ways. Self-stiffening occurs in elastomers that crystallize or in block copolymers composed of one block in the elastomeric state and two or more blocks in the glassy or crystalline state. Fillers also cause stiffening. Some crystalline organic compounds which contain a beta-naphthyl group are particularly effective. The conditions under which the crystals form in the elastomer affect the degree of stiffening. Under favorable conditions, about 3 percent crystalline phenyl-beta-naphthylamine (PBNA) stiffens rubber to about the same degree as 40 phr carbon black. Since the crystals can be extracted with organic solvents, the stiffening effect is reversible. Studies with PBNA and results in the literature suggest that (1) stiffening of elastomers by fillers is primarily a physical phenomenon, (2) the effectiveness of a filler is determined by both surface area and interfacial forces between the filler and elastomer, (3) surface area is determined by the geometry of the particles, (4) interfacial forces depend on the number of atoms per unit surface area that are sufficiently close to atoms in the elastomer molecule to develop a substantial force, (5) interfacial forces are maximized when the atoms in the surface layer of the filler have a geometric structure similar to the atoms in the elastomer, and (6) the elastomer molecule or segments of it must have sufficient mobility to permit alignment with the filler surface to achieve attraction at as many points as possible.

11145. Straty, G. C., **Bellows-sealed valve for reactive gases at moderately high pressures,** *Rev. Sci. Instr.* **40,** No. 2, 378-379 (Feb. 1969).

Key words: Bellows; fluorine; high pressure; packless; reactive; valve.

A relatively simple and inexpensive laboratory size bellows sealed valve for use at pressures in excess of 3000 psi is described. The valve is a modification of one of several commercially available, small high pressure valves and uses a number of standard components.

11146. Strobridge, T. R., **Refrigeration at 4 K,** *Proc. 1968 Summer Study on Superconducting Devices and Accelerators, Brookhaven National Laboratory, Upton, Long Island, N.Y., June 10-July 19, 1968,* Part I, BNL 50155 (C-55), pp. 193-204 (Clearinghouse for Federal Scientific and Technical Information, Springfield, Va., Apr. 1969, $3.00).

Key words: Claude; cryogenics; Gifford-McMahon; helium; Joule-Thomson; liquid; power; refrigeration; Simon; size; Stirling.

Superconducting accelerators and support elements are being considered for the next generation of particle accelerators. Until practical materials with higher transition temperatures become a reality, refrigeration in the neighborhood of 4 K will be required for these superconducting devices. This paper summarizes a lecture given on 4 K refrigeration covering evaporating liquid helium baths, the Simon process, the Joule-Thomson, Brayton, Claude, Stirling, and Gifford McMahon cycles. Also included were examples of analysis and descriptions of modern refrigerators and their components.

11147. Strobridge, T. R., **Review of the cryogenics session—second week of the Brookhaven summer study on superconducting devices and accelerators,** *Proc. 1968 Summer Study on Superconducting Devices and Accelerators, Brookhaven National Laboratory, Upton, Long Island, N.Y., June 10-July 19, 1968,* Part 1, BNL 50155 (C-55), pp. 368-375 (Clearinghouse for Federal Scientific and Technical Information, Springfield, Va., Apr. 1969, $3.00).

Key words: Cryogenics; cryopump; cryostat; electrical lead; heat transfer; mechanical properties; refrigeration; safety; superconductivity; superfluid.

This paper reviews the lectures given during the cryogenics session at the Brookhaven Summer Study on Superconducting Devices and Accelerators. Lectures were given on the low temperature mechanical properties of both metallic and nonmetallic structural materials, cryostat design, cryopumping, electrical lead design, safety, superfluid helium, heat transfer to helium I and finally three talks were given on refrigeration. The experts opinions are outlined and the areas which most urgently require further research and development are listed.

11148. Stromberg, R. R., **Polymer adsorption on substrates,** (Proc. Symp. Interface Conversion Polymer Coatings, General Motors Research Laboratories, Detroit, Mich., Oct. 1967), Chapter in *Interface Conversion for Polymer Coatings,* P. Weiss and G. D. Cheever, eds., pp. 321-337 (American Elsevier Publ. Co., Inc., New York, N.Y., 1969).

Key words: Adsorption; configuration of adsorbed polymer; interface; polymer adsorption.

Polymer adsorption studies, theoretical and experimental, at the National Bureau of Standards are reviewed. Both of these studies are primarily concerned with changes in the configuration of the molecule upon adsorption and with the nature of the interaction with the surface. The experimental methods include studies of the extension of the adsorbed polymer molecule normal to the surface and the concentration of polymer in the film. The measurement techniques are ellipsometry and internal reflection spectroscopy. Also discussed are studies of the fraction of segments of the polymer chain attached to a surface. This quantity is determined by measuring a shift of an absorption peak in the infrared spectra that is caused by the attachment. Reversibility of adsorption and rates of adsorption and desorption, measured using radioactive tracer techniques are also briefly mentioned.

11149. Sugar, J., **Nuclear magnetic dipole moment of ^{165}Ho,** *J. Opt. Soc. Am.* **58,** No. 11, 1519-1523 (Nov. 1968).

Key words: Holmium; hyperfine structure; nuclear moment.

The first energy interval of the $4f^{11}6s$ configuration of Ho II was recently found by N. Spector and J. Sugar to be 637.8 cm^{-1}. The hfs of four of the lines defining this interval have been measured with an HYPEAC spectrometer at a resolution of 600 000. Seven independent equations relating the splitting factors a_{6s}, a_{4f}, and b_{4f} to the measured hfs were derived. Known values of a_{4f} and b_{4f} from Ho I (deduced in an atomic beam magnetic resonance experiment) were inserted in these equations, giving $a_{6s} = 0.4437$ cm^{-1} (corrected for core polarization) with a probable error of 0.0004 cm^{-1}. From a_{6s}, a value for the nuclear magnetic dipole moment $\mu_I = (3.94 \pm 0.05)\mu_N$ was derived ($1\ \mu_N = 5.05050 \times 10^{-27}$ JT^{-1}). The uncertainty in μ_I is the rms deviation due to uncertainties in a_{6s} and in $\psi_{6s}^2(0)$, the value of the probability density of the 6s-electron at the nucleus.

11150. Swanson, N., Codling, K., **Excitation of K-shell electrons in Be by soft x-rays and 20-keV electrons,** *J. Opt. Soc. Am.* **58,** No. 9, 1192-1194 (Sept. 1968).

Key words: Be; BeO; electron energy loss; fine structure; K edge; x-ray absorption.

The soft x-ray absorption spectra of Be and BeO were measured near the K edge using the NBS 180 meV synchrotron as a background continuum source. The energy loss spectrum of 20 keV electrons transmitted through thin Be films at zero scattering angle was measured in the corresponding 100-170 eV energy loss range. The K edges of Be and BeO measured by x-ray absorption were at 112.1 ± 0.2 eV and 118.4 ± 0.2 eV respectively. The Be K edge in the electron energy loss spectrum was at 111.7 ± 0.4 eV. The positions of maxima in the absorption fine structure determined by the two techniques were also in good agreement. The indicated uncertainties represent extended probable errors.

11151. Swartzendruber, L. J., **Variable temperature Mössbauer effect spectrometer with provision for longitudinal external fields,** *Nucl. Instr. Methods* **69,** 101-105 (1969).

Key words: Instrumentation; iron; low temperature; magnetic field; Mössbauer effect; spectrometry.

A Mössbauer effect spectrometer design for obtaining spectra with the absorber in a longitudinal external magnetic field is described. A superconducting magnet is the source of the field. The absorber temperature can be varied between 300 K and about 1.5 K and, independently, the source temperature can be varied between 300 K and about 10 K above the absorber temperature.

11152. Tanttila, W. H., Mahler, R. J., James, L. W., **Magnetic parametric nuclear spin saturation,** *Appl. Phys. Letters* **13,** No. 1, 27-29 (July 1, 1968).

Key words: Magnetic transitions; magnetic and quadrupole split energy levels; nuclear magnetic resonance; parametric.

Magnetic $\Delta m = \pm 2$ nuclear spin transitions are observed when an r.f. magnetic field at the frequency $(Em_{m-2} - E_m)/h$ is applied parallel to an external magnetic field in a crystal where the c-axis is perpendicular to the external magnetic field.

11153. Tauber, S. J., **Imprecision—problems for information processing,** *Am. Doc.* **19,** No. 4, 413-414 (Oct. 1968).

Key words: Experimental conditions; imprecision; information system design; levels of abstraction; mnemotechnics; semantics; specificity.

Some of the characteristics of imprecision which affect information storage and retrieval are pointed out and discussed in the areas of numeric values, experimental conditions, and semantics.

11154. Taylor, J. K., **Modern electrochemistry,** *Ind. Res.* **10,** No. 10, 68-74 (Oct. 1968).

Key words: Chemical analysis; coulometry; electrochemical analysis; electrochemical instrumentation; ion-selective electrodes; polarography.

Electrochemical methods of analysis are especially attractive because of the sensitivity and accuracy they provide. Methods based on measurement of resistance, current, and voltage singly or in combination provide a variety of techniques applicable from trace determinations to assays for major constituents. The methods are especially applicable to automation, process control, and remote-location monitoring situations. The recent advent of ion-selective electrodes promises to increase the scope of electroanalysis, especially for routine determination of moderate accuracy. The techniques most frequently used at the present time are described and discussed with reference to the areas of their greatest utility.

11155. Thomas, A. M., **Monte Carlo study of vacuum vane gauge design criteria,** *J. Vacuum Sci. Technol.* **5,** No. 6, 187-193 (Nov.-Dec. 1968).

Key words: Molecular flow; Monte Carlo; vacuum; vacuum gauge; vane gauge.

A Monte Carlo method is presented by which the effects of molecular motion in free molecular flow systems of various geometries may be studied. The geometry used in this study is that of a straight tube of circular cross section with a circular vane co-axial with and placed at various distances from the end of the tube. Calculations are made of the ratio of the force on the vane to the isotropic pressure at the opposite end of the tube. Parameters which are varied are tube length, tube wall thickness, distance to the vane, and radius of the vane; all of which are measured in terms of one tube radius. This study revealed that, for short, thin walled tubes and for a large vane, the force on the vane is fairly insensitive to the amount of separation between the tube and the vane as long as this separation is less than about one half a tube radius. However, for longer tubes, the force on the vane falls off quite rapidly as the vane is moved away from the tube end. Also, for tubes with thicker walls, the force-to-pressure ratio increases as the vane is first moved away from the tube and reaches a maximum which may be greater than twice the original value.

11156. Thomas, R. N., **Symposium on Wolf-Rayet stars: a summary,** *Astrophysical Letters* **2,** No. 3, 147-148 (Oct. 4, 1968).

Key words: Wolf-Rayet stars.

This paper is a brief summary of the Symposium on Wolf-Rayet stars held at the Joint Institute for Laboratory Astrophysics 10-15 July 1968 under joint sponsorship of JILA, the Smithsonian Astrophysical Observatory, Harvard College Observatory, and American Astronomical Society. The complete symposium was published in National Bureau of Standards Special Publication 307, Wolf-Rayet Stars, issued December 1968, available by purchase from the Superintendent of Documents, Government Printing Office, Washington, D.C. 20402 at $3.00 a copy.

11157. Thompson, B. A., LaFleur, P. D., **Rapid group radiochemical separations for activation analysis of steels,** *Anal. Chem.* **41,** No. 6, 852-855 (May 1969).

Key words: Activation analysis; group separations; radiochemical separations; steels.

Rapid group radiochemical separation procedures based on solvent extraction have been developed for the determination of W, Mo, Cu, Cr, As, Co, Sb, and Ga in steel and cast iron. The procedures have been applied to the analysis of NBS Standard Reference Material steels and give results in agreement with the NBS certified values. The precision obtained is routinely ±10 percent at the 95 percent confidence level and in favorable situations can be ±2 percent.

11158. Tipson, R. S., Cohen, A., **Reaction of some sulfonic esters of D-mannitol with methoxide; synthesis of 2,3:4,5-dianhydro-D-iditol,** *Carbohydrate Res.* **7,** 232-243 (1968).

Key words: Expoxide formation; D-mannitol; methoxide; sulfonic esters; 2,3:4,5-dianhydro-D-iditol.

3,4-Di-*O*-(methylsulfonyl)- and 3,4-di-*O*-*p*-tolylsulfonyl-D-mannitol and their 1,2,5,6-tetraacetates have been synthesized and crystallized. By the action of methanolic barium methoxide during 2 h at 25°, each of these compounds is converted into 2,3:4,5-dianhydro-D-iditol, the structure of which is assigned on the basis of chemical and physical properties, including n.m.r. evidence.

11159. Tipson, R. S., West, B. F., Brady, R. F., **Acid-catalyzed hydrolysis of isopropylidene acetals of some 2-pentuloses and 2-hexuloses,** *Carbohydrate Res.* **10,** 181-183 (1969).

Key words: Acid catalysis; hydrolysis; isopropylidene acetals; *spiro*-fused structures; 2-hexuloses; 2-pentuloses.

The rate of hydrolysis with 100 m*M* oxalic acid (aqueous) at 65 °C was determined for the isopropylidene acetals of two 2-pentuloses and four 2-hexuloses. The compounds studied were found to fall into three groups according to the time to complete hydrolysis to the parent sugar: (a) 1,2:3,4-diacetal of D-*erythro*-pentulofuranose (~1.25 hr); (b) 1,2:4,5-diacetals of β-D-*ribo*-hexulopyranose, β-D-*erythro*-2,3-hexodiulo-2,6-pyranose, and β-D-*arabino*-hexulopyranose (2-3 hr); and (c) 2,3-acetal of β-D-*threo*-pentulofuranose and 2,3:4,5-diacetal of β-D-*arabino*-hexulopyranose (8 hr). This shows that the presence of two *spiro*-fused, 5-membered rings induces instability in the 1,2-isopropylidene group. If the 1,2-*spiro* structure is absent and there is a hydroxymethyl group attached at C-2, the rate of hydrolysis is lowest. Thus, determination of the rate of acid-catalyzed hydrolysis is a simple, rapid method for determining (a) the presence or absence of a *spiro* structure involving C-1 and C-2 in cyclic acetals of 2-ketoses, and (b) the presence of a furanoid ring if the *spiro* structure is present.

11160. Toots, J., Fowler, H. A., Marton, L., **Reflectance and $1/\epsilon$ resonance of beryllium in the far ultraviolet,** *Phys. Rev.* **172,** No. 3, 670-676 (Aug. 15, 1968).

Key words: Beryllium; far-ultraviolet; optical properties; reflectance; stopping power.

The reflectance of evaporated Be layers has been measured after 3 min. exposure to ambient pressures of $\leq 3 \times 10^{-7}$ torr, for the wavelength range of 480-1200 Å, for a spread of angles between 20 and 80°. These values give n and k by calculation; also, from these, ϵ_1, ϵ_2, Re $(1/\epsilon)$, and Im $(1/\epsilon)$. The last two functions show good agreement with an inverted Drude-Sellmeier resonance formula. The center-frequency of the resonance falls precisely on 18.4 eV ± 0.1 eV, corresponding to the natural plasma-resonance frequency of a free-electron-gas with 2.0 electrons per atom; this confirms a 1948 prediction by A. Bohr. Half-width of the resonance is measured as 4.7 eV; this value is also obtained, within ±10 percent, from a sum-rule approximation. The value corresponds to a decay time (for intensity) of the plasma oscillation of about 1.3×10^{-16} seconds. Argand-diagram display, and the "longitudinal" Kramers-Kronig relationship, are developed from the data.

11161. Torrance, K. E., Orloff, L., Rockett, J. A., **Experiments on natural convection in enclosures with localized heating from below,** *J. Fluid Mech.* **36,** Part 1, 21-31 (1969).

Key words: Enclosures; flow visualization; modeling; natural convection.

An experimental study was made of the steady state natural convection induced in enclosures by a small hot spot centrally located on the floor. Enclosures of rectangular and circular floor plan were employed, with height equal to major radius of the floor plan. The movement of air within the chambers was made visible by adding metaldehyde dust particles and illuminating with an intense light beam. The Grashof number (Gr) based on hot spot temperature and enclosure height ranged from 8×10^5 to 1×10^{10}. Laminar flows were observed for Gr $\lesssim 1.2 \times 10^9$. The experimental flows in the circular chamber are compared in a companion paper with theoretically calculated flows (Torrance and Rockett (1968)). In the region of laminar flows the agreement was excellent. The present paper notes certain similarities in the flows in rectangular and circular geometries. The disturbing effect of a slight heating of one wall of the rectangular enclosure was also investigated. Measurements were made of heat transfer from the hot spot to the air in the chamber.

11162. Torrance, K. E., Orloff, L., Rockett, J. A., **Numerical study of natural convection in an enclosure with localized heating from below—creeping flow to the onset of laminar instability,** *J. Fluid Mech.* **36,** Part 1, 33-54 (1969).

Key words: Circular cylinder; enclosures; natural convection; numerical.

An analytical study was made of the natural convection induced in an enclosure by a small hot spot centrally located on the floor. The enclosure was a circular cylinder, vertically oriented, with height equal to radius. A Prandtl number of 0.7 (air) was assumed; the Grashof number (Gr) was based on cylinder height and hot spot temperature. The equations of fluid flow in axisymmetric cylindrical coordinates were simplified with the Boussinesq approximation. The equations were solved numerically with a computationally stable, explicit method. The computation, starting from quiescent conditions, proceeded through the initial transient to the fully developed flow. Solutions were obtained for Gr from 4×10^4 to 4×10^{10}. The calculated flows were compared with the experimental flows presented in a companion paper, Torrance, Orloff and Rockett (1968). The experimental flows were laminar for $Gr \lesssim 1.2 \times 10^9$; turbulence was observed above this value. In the laminar flow region ($Gr \lesssim 1.2 \times 10^9$) agreement between the theoretical and experimental flow patterns was excellent. When extended into the experimentally observed turbulent range ($Gr = 4 \times 10^{10}$) the theoretical flow developed a periodic vortex shedding, suggestive of the onset of transition.

11163. Travis, J. C., Spijkerman, J. J., **Mössbauer spectroscopy with Ni^{61},** Chapter in *Mössbauer Effect Methodology* **4,** 237-259 (Plenum Press Inc., New York, N.Y., 1968).

Key words: Chemical shifts; electronic configurations; internal magnetic fields; magnetic fields; magnetic moment ratio; nickel Mössbauer spectroscopy; nuclear hyperfine interactions; quadrupole splitting; single line source.

The practical application of Mössbauer spectroscopy to the study of nickel compounds has been retarded by two factors: (1) the late discovery of a suitable, single line source, and (2) the short half lives of both possible parent isotopes of ^{61}Ni. A suitable source of 15 percent Cr in Ni is activated by one hour of exposure to 100 MeV bremsstrahlung in the NBS linear electron accelerator. The source has a fractional effect of 0.1 ± 0.02, and yields an experimental linewidth of 0.097 ± 0.002 cm/s when extrapolated to zero thickness in source and absorber.

Adequate data have been obtained to determine a magnetic moment ratio, $\mu_e \mu_g = -0.568 \pm 0.055$, and an estimate for the change in the nuclear charge radius, $\delta R/R = -2.5 \times 10^{-4}$. The ground state quadrupole moment is negligible for Mössbauer spectroscopy. Spectra which illustrate pure magnetic, pure quadrupolar, and mixed (Laves phase) interactions have been obtained.

This paper discusses the preparation of a single line source, the evaluation of nuclear parameters, theoretical studies of the nuclear hyperfine interactions, and theoretical prediction of the electric field gradient tensor.

11164. Trembath, C. L., Wait, D. F., Engen, G. F., Foote, W. J., **A low-temperature microwave noise standard,** *IEEE Trans. Microwave Theory Tech.* **MTT-16,** No. 9, 709-714 (Sept. 1968).

Key words: Cryogenic; microwave; noise; standard.

An x-band thermal noise source is described which consists of a waveguide termination, cooled in a cryogenic environment, along with temperature and pressure monitors and controls. With liquid helium as the cryogen, the effective noise output at the room temperature flange can be set to values around the boiling point of helium (4.2 K) with an accuracy of ±0.03 K. With liquid nitrogen as the cryogen, the output temperature can be set to values around 77 K with an accuracy of ±0.16 K.

This accuracy is made possible by several unique features. First, the terminating waveguide section is a vapor bulb thermometer with the absorbing load surrounded with the cryogenic liquid. Second, heat exchangers are used to permit an unusually short waveguide transition section between cryogenic and room temperature. Third, an absolute pressure regulator is used to control the cryogen boil-off rate resulting in a temperature stability of 0.002 K for helium and 0.02 K for nitrogen.

At present, the useful accuracy of the standard is limited to ±0.1 K because of uncertainties in the insertion loss (about 0.001 dB) of mating room temperature flanges.

11165. Tsai, D. H., Beckett, C. W., **Shock wave propagation in a two-dimensional crystalline lattice,** (Proc. Intern. Union of Theoretical and Applied Mechanics: Intern. Symp. Behavior of Dense Media Under High Dynamic Pressure, Paris, France, Sept. 11-15, 1967), Chapter in *The Behavior of Dense Media Under High Dynamic Pressure,* pp. 99-108 (Gordon and Breach, Science Publ. Inc., New York, N.Y., 1968).

Key words: Energy calculations; Grüneisen parameter; lattice stability; shock wave propagation; thermal oscillations; two-dimensional lattice dynamics.

Lattice dynamics has been applied to the study of the propagation of a strong, one-dimensional shock wave in a two-dimensional face-centered cubic lattice. The shock was generated at the free surface of the lattice by impact, and propagated into the lattice in the longitudinal direction perpendicular to the free surface. The transverse motion of the lattice points allowed the shock wave to be scattered and the compressive energy to be distributed between the longitudinal and transverse degrees of freedom. In our calculation, a Morse type potential function between pairs of lattice points was employed, and the interactions were assumed to extend to the fourth-neighbors. The equations of motion of the lattice points were solved by an approximate numerical method, and from the solutions, the dynamical behavior of the shock wave, the vibrational energy, and the Grüneisen parameter in the shock compressed region were obtained. These results were compared with similar results for a one-dimensional lattice model.

11166. Tsang, T., **Self-consistent correlation function approximation in Ising ferromagnets,** *Physica* **42,** 1-11 (1969).

Key words: Ising ferromagnet; molecular field approximation; pair correlation function; three-dimensional ferromagnet; two-dimensional ferromagnet.

Two modifications have been proposed to improve the Weiss molecular field approximation of Ising ferromagnets: a pair of central spins were examined to yield self-consistent equations for pair correlation functions; the nearest neighbors of the central spins are also taken in account. The method, which needs very little computational work, has been applied to the square and cubic Ising ferromagnets, and the results are in good agreement with Onsager's exact solution and the power series expansions.

11167. Tsang, T., Farrar, T. C., **Nuclear magnetic relaxation studies of internal rotations and phase transitions in borohydrides of lithium, sodium, and potassium,** *J. Chem. Phys.* **50,** No. 8, 3498-3502 (Apr. 15, 1969).

Key words: Lithium borohydride; nuclear magnetic relaxation; phase transition; potassium borohydride; sodium borohydride; spin lattice relaxation time.

Proton spin-lattice relaxation times, T_1, have been measured as a function of temperature for KBH_4, $NaBH_4$ and $LiBH_4$. For $NaBH_4$ and KBH_4, ^{23}Na and ^{11}B relaxation measurements were also made. In all cases, the magnetization recovery is approximately exponential. Correlation times, τ_c, derived from T_1 data were used to calculate activation energies, V, for BH_4^- ion reorientations, and the corresponding rms errors of the individual values involved. For the cubic phase of KBH_4, V = 14.8 ± 0.4 kJ/mol (3.55 ± 0.1 kcal/mol) from measurements on proton and ^{11}B. For $NaBH_4$, V was found to be 11.2 ± 0.5 and 14.8 ± 0.7 kJ/mol (2.7 ± 0.1 and 3.5 ± 0.2 kcal/mol) for the high (cubic) and low temperature (tetragonal) phases; an anomaly in τ_c was observed at temperatures slightly below the phase transition, and may be interpreted as a relatively sudden change in V associated with the phase transition. In $LiBH_4$, a rather broad minimum was observed for the proton T_1 vs. temperature; this has been interpreted as due to two inequivalent BH_4^- tetrahedra with activation energies of 20 ± 1 and 16 ± 1 kJ/mol (4.7 ± 0.3 and 3.8 ± 0.3 kcal/mol). The proton and ^{11}B nuclei are relaxed by magnetic dipolar interactions, but quadrupolar fluctuations are the dominating relaxation mechanism for ^{23}Na in the cubic phase of $NaBH_4$.

11168. Tsang, T., Farrar, T. C., Rush, J. J., **Proton magnetic resonance and hindered rotation in phosphonium halides and ammonium iodide,** *J. Chem. Phys.* **49,** No. 10, 4403-4406 (Nov. 1968).

Key words: Activation energy; ammonium iodide; hindered rotation; nuclear magnetic relaxation; phosphonium halides; proton; proton second moment; spin-lattice relaxation.

Proton spin-lattice relaxation times, T_1, and second moments have been measured as a function of temperature for the phosphonium halides and ammonium iodide. Correlation times τ_c derived from the relaxation data were used to obtain activation energies for the reorientation of the phosphonium and ammonium ions. The activation energies for PH_4Cl, PH_4Br, and PH_4I are $(3.0\pm0.2)\times10^4$, $(3.1\pm0.1)\times10^4$ and $(3.06\pm0.04)\times10^4$ joules per mole respectively, indicating little change in barrier with halide ion. The frequency factors, however, do appear to vary significantly from crystal to crystal. These results are in marked contrast with previous results for the ammonium halides and suggest that non-electrostatic repulsive forces are important in the phosphonium salts. The activation energy for NH_4^+ ion reorientation in the tetragonal phase (Phase III) of NH_4I is found to be $(1.34\pm0.04)\times10^4$ joules per mole. The present results are compared with previous spectroscopic and structural results.

11169. Tsang, W., **Thermal decomposition of 3,4-dimethylpentene-1, 2,3,3-trimethylpentane, 3,3-dimethylpentane, and isobutylbenzene in a single pulse shock tube,** *Intern. J. Chem. Kinetics* **1,** 245-278 (1969).

Key words: Bond energy; decomposition; free radicals; heat of formation; hydrocarbon; isobutylbenzene; pre-exponential factor; pyrolysis; single pulse shock tube; 3,3-dimethylpentane; 3,4-dimethylpentene-1; 2,3,3-trimethylpentane.

Several hydrocarbons have been pyrolyzed in a single pulse shock tube. Rate parameters for the main bond breaking step have been found to be

$$k\{iC_3H_7-CH(CH_3)CH{=}CH_2 \rightarrow iC_3H_7\cdot +$$

$$\cdot CH(CH_3)CH{=}CH_2\} = 10^{15.70} \exp(-32{,}500/T) \text{ sec}^{-1}$$

$$k\{iC_3H_7-C(CH_3)_2C_2H_5 \rightarrow iC_3H_7\cdot +$$

$$\cdot C(CH_3)_2C_2H_5\} = 10^{16.15} \exp(-35{,}900/T) \text{ sec}^{-1}$$

$$k\{C_2H_5-C(CH_3)_2C_2H_5 \rightarrow C_2H_5\cdot +$$

$$\cdot C(CH_3)_2C_2H_5\} = 10^{16.57} \exp(-38{,}800/T) \text{ sec}^{-1}$$

$$k\{iC_3H_7-CH_2C_6H_5 \rightarrow iC_3H_7\cdot +$$

$$\cdot CH_2C_6H_5\} = 10^{15.23} \exp(-34{,}800/T) \text{ sec}^{-1}$$

In combination with similar studies carried out earlier and through application of the well-established experimental rule $(k_r^2(AB)/k_r(AA)k_r(BB))^{1/2} \sim 2$ where A and B are radicals and the rate constants are for the combination of these radicals, rate parameters for the thermal decomposition of all the hydrocarbons formed from any pair of the following radicals: methyl, ethyl, isopropyl, *t*-butyl, *t*-amyl, allyl, methylallyl, and benzyl have been calculated. The available calculated and experimental values of the decomposition rate constants are in excellent agreement. It appears that, with the possible exception of reactions involving the ejection of methyl radicals, the frequency factors per bond are nearly constant, depending only upon the type of carbon–carbon bond that is being broken. These values are all lower than those expected from the radical recombination rates.

Heats of formation of ethyl, *t*-amyl, benzyl, methylallyl, n-propyl, *s*-butyl, isobutyl, neopentyl, and 3-pentyl radicals have been derived.

Rate parameters for the decomposition of some simple ketones and ethers have also been estimated.

11170. Turgel, R. S., **A comparator for thermal ac-dc transfer standards,** *ISA Trans.* **6,** No. 4, 286-292 (1967).

Key words: Ac; calibration; dc; intercomparison; thermoelement; transfer standard.

Thermal transfer standards play an important role in precision a-c measurements. They are calibrated by intercomparison with standards of known ac-dc difference. A comparator is described that simplifies such routine calibrations. A sequence of null balances in the measuring circuit operates a simple analog computer which indicates the result of the intercomparison directly in parts per million of ac-dc difference.

11171. Van Blerkom, D., Hummer, D. G., **A non-LTE theory of overlapping lines near the series limit,** *Astrophys. J.* **154,** No. 2, 741-750 (Nov. 1968).

Key words: Band model; line formation; planetary nebulae.

The effects of overlapping on the formation of spectral lines near the series limit are investigated through the introduction of a band model. Numerical solutions are obtained which show that the source function can be increased by a factor two for $\epsilon = 0.1$ and by much larger amounts for smaller ϵ. A criterion is presented to check when overlapping is likely to be important.

11172. Veillon, C., Margoshes, M., **An evaluation of the induction-coupled, radio-frequency plasma torch for atomic emission and atomic absorption spectrometry,** *Spectrochim. Acta* **23B,** 503-512 (1968).

Key words: Atomic absorption spectrometry; atomic emission spectrometry; detection limits; interelement effects; plasma torch; radio-frequency; spectrochemical analysis.

A study has been made of the radio-frequency plasma torch as a source of atoms for emission and absorption spectrochemical analysis. The factors evaluated include sensitivity, limits of detection, interelement effects, limitations, and general convenience. In agreement with other reports, the plasma torch was found to give useful emission signals for several elements which are difficult to excite in chemical flames, such as B, Ta, and Ti. The value of the source for atomic absorption spectrometry was found to depend on the availability of bright line sources. Pronounced interelement effects were found, affecting particularly the emission signals. In most cases, these interelement effects were enhancements of the emission, although in one case a suppression was observed. Except for a few refractory elements, the plasma torch does not appear to be a suitable replacement for the chemical flame.

11173. Veillon, C., Margoshes, M., **A pneumatic solution nebulization system producing dry aerosol for spectroscopy,** *Spectrochim. Acta* **23B,** 553-555 (1968).

Key words: Atomizer; nebulizer; pneumatic aspirator; sample introduction; solvent removal; spray.

An efficient sample introduction system was developed for aqueous solutions. It is made up of a pneumatic nebulizer, a heated chamber for solvent evaporation, and a chilled condenser for solvent removal. Features include low gas flow rate, high efficiency, and elimination of the solvent. Overall efficiency is 35 percent.

11174. Vicentini-Missoni, M., Sengers, J. M. H. L., Green, M. S., **Thermodynamic anomalies of CO_2, Xe, and He^4 in the critical region,** *Phys. Rev. Letters* **22,** No. 9, 389-393 (Mar. 3, 1969).

Key words: Chemical potential; critical exponents; critical parameters; critical region; equation-of-state; fluids; scaling law; specific heat.

A closed-form equation for the chemical potential as function of density and temperature, based on the scaling idea is fitted to experimental data in the critical regions of CO_2, Xe and He-4, optimizing δ, T_c and two adjustable constants. Values obtained for the critical exponents and the two constants vary only slightly from substance to substance; we find $\beta = .35 - .36$, $\delta = 4.4 - 4.6$, $\gamma = 1.24 - 1.26$, $\alpha = 0.04 - 0.05$, $\Gamma/\Gamma' = 3.6 - 4.4$, $\Delta = 2.6 - 3.3$. Agreement with previous estimates and with independent C_v and optical density gradient measurements is discussed.

11175. Vieth, D. L., Yakowitz, H., **Tensile loading device for Kossel microdiffraction and metallography,** *Rev. Sci. Instr.* **39,** No. 12, 1929-1931 (Dec. 1968).

Key words: Instrument design; Kossel x-ray method; metallography; strain measurement; tensile testing; x-ray microdiffraction.

A loading device used primarily in conjunction with Kossel (divergent beam) x-ray diffraction is described. The device is compatible with any standard upright metallograph as well. It is four inches (10.1 cm) in diameter and accommodates specimens one inch in reduced section by 1/4 inch wide. The device utilizes small load cells having ranges of 0 to 10 pounds (44.5N) and 0 to 100 pounds (445N) respectively. Load cell error is ±0.5 percent of the full load capacity. Load changes of 0.2 percent of load capacity can be observed. The load device is mechanically and electrically stable. Loads are read on a standard commercial universal indicator.

11176. Wait, D. F., **Thermal noise from a passive linear multiport,** *IEEE Trans. Microwave Theory Tech.* **MTT-16,** No. 9, 687-691 (Sept. 1968).

Key words: Available power ratio; microwave multiport; nonreciprocal multiports; thermal noise.

The effective noise temperature T_n of a linear passive multiport at uniform temperature T is shown to be $T_n = AT$, where T_n is referred to the output port. The absorption coefficient A is given for arbitrarily mismatched input-ports in terms of scattering matrices and reflection coefficients. A simplified expression is given for multiports with nearly reflectionless port terminations. A method for precise measurement of A is pointed out. The results apply to either reciprocal or nonreciprocal junctions. The noise correlation between ports was calculated for multiports having reflectionless port terminations. The correlation is shown to be proportional to the physical temperature of the multiport and to the appropriate matrix element of $\mathbf{B} \equiv \mathbf{1} - \mathbf{SS}^{\dagger}$. where S is the scattering matrix of the junction and $S^{\dagger}$ is the Hermitian conjugate of the scattering matrix.

11177. Wait, D. F., Nemoto, T., **Measurement of the noise temperature of a mismatched noise source,** *IEEE Trans. Microwave Theory Tech.* **MTT-16,** No. 9, 670-675 (Sept. 1968).

Key words: Effective temperature; measurement; mismatched generators; noise.

A method is suggested which can measure the available power (or the effective temperature) of a noise generator independent of its reflection coefficient. A system utilizing a compensation generator and a tuned three-port circulator, is constructed at X-band and evaluated for a noise generator of about 10,000 K. The error analysis and the experimental results indicate that the effective temperature of this generator, with a reflection coefficient of 0.5, can be measured within one-half of one percent in addition to the uncertainty of a standard needed to calibrate the system.

11178. Waterstrat, R. M., **Crystal structure transformations in VPt produced by plastic deformation at room temperature,** *Trans. Met. Soc. AIME* **245,** 1360-1361 (June 1969).

Key words: Atomic ordering; crystal structure; phase transformations; plastic deformation.

A crystallographic transformation has been produced in the phase VPt by plastic deformation at room temperature. In alloys annealed at 1300 °C the phase VPt has a B19 (AuCd) type structure but plastic deformation of this phase produces a transformation to either an ordered structure of the $L1_0$ (CuAu) type or to a disordered face-centered cubic structure. It appears that alloy composition and the extent of cold working may be factors which determine the type of structure formed.

11179. Waterstrat, R. M., **Evaluation of a gallium-palladium-tin alloy for restorative dentistry,** *J. Am. Dental Assoc.* **78,** No. 3, 536-541 (Mar. 1969).

Key words: Dental amalgam; dental materials; gallium alloy; palladium alloy; restorative dentistry.

A gallium-palladium-tin alloy has been developed which may possibly be used for restorative dentistry. The alloy is handled using techniques very similar to those used with conventional dental amalgams. The gallium alloy, however, has a higher strength and a much greater resistance to flow or creep under an applied load. In addition the gallium alloy wets tooth structure and has a thermal expansion coefficient which is fairly close to that of human teeth. Much more clinical and biological testing will be needed before the alloy can be recommended for general use.

11180. Weir, C. E., Piermarini, G. J., Block, S., **Crystallography of some high-pressure forms of C_6H_6, CS_2, Br_2, CCl_4, and KNO_3,** *J. Chem. Phys.* **50,** No. 5, 2089-2093 (Mar. 1, 1969).

Key words: High-pressure; polymorphism; single-crystal; x-ray diffraction.

From single crystal x-ray diffraction at high pressure and room temperature, unit-cell and space-group data were obtained for the following materials: C_6H_6, I–orthorhombic, a = 7.17, b = 9.28, c = 6.65, Pbca; CS_2–orthorhombic, a = 6.16, b = 5.38, c = 8.53, Cmca; Br_2–orthorhombic, a = 8.54, b = 6.75, c = 8.63, Cmca; CCl_4, I–rhombohedral, a = 14.27, $\alpha = 90°$; CCl_4, II–monoclinic, a = 22.10, b = 11.05, c = 25.0, $\beta = 114°$, Cc or $C2/_c$; CCl_4, III–orthorhombic, a = 11.16, b = 14.32, c = 5.74, $C222_1$; KNO_3, III–rhombohedral, a = 4.31, $\alpha = 78°54'$; KNO_3, IV(?)–orthorhombic, a = 5.58, b = 7.52, c = 6.58, $P2_1nb$ or Pmnb. All unit-cell dimensions are given in Å with estimated uncertainties of ± 2 in the last decimal place given and uncertainties of ± 0.5 deg. in angles.

11181. Weisman, I. D., Swartzendruber, L. J., Bennett, L. H., **Resonance studies in ferromagnetic Fe_2B and Fe_2Zr,** *Phys. Rev.* **177,** No. 2, 465-471 (Jan. 10, 1969).

Key words: Anisotropy; electric field gradient; Fe_2B; Fe_2Zr; ferromagnetism; hyperfine field; nuclear magnetic resonance; quadrupole interactions; spin waves.

The hyperfine magnetic fields and quadrupole interactions in Fe_2B and Fe_2Zr are explored by nuclear magnetic resonance and the Mössbauer effect. As in previous work, an anisotropy is found in the Mössbauer spectra which can be interpreted as a superposition of an anisotropic magnetic field and electric field gradient from two magnetically inequivalent Fe sites. The two magnetic fields are found (with indicated extended uncertainties) to be (252 ± 2) dT and (244 ± 2) dT at 4.2 K. The resonance frequency shows a $T^{3/2}$ dependence with some low temperature deviations which can be understood in terms of a gap arising from magnetocrystalline anisotropy and spin wave demagnetization. The measured pressure variations, $\delta\gamma/\delta p$, of the ^{11}B and ^{91}Zr frequencies (and their extended uncertainties) are respectively (-21 ± 2) and (31 ± 2) Hz-(bar)$^{-1}$.

11182. Weiss, A. W., **Series perturbations and atomic oscillator strengths: the ^2D series of Al I,** *Phys. Rev.* **178,** No. 1, 82-89 (Feb. 5, 1969).

Key words: Configuration interaction; oscillator strength; series perturbations.

A model calculation has been made of the effects of perturbations of the $3s^2nd$ series of aluminum by the $3s3p^2$ ^2D-term. The model employed is the traditional one of configuration interaction among the independent particle model representations of the relevant discrete states, with Hartree-Fock functions being used to compute the necessary matrix elements. It is found that, while in the Hartree-Fock approximation the $3s3p^2$ term is bound and embedded in the $3s^2nd$ series, the configuration interaction gives rise to a new autoionizing state just beyond the series limit. This state, which is approximately 50 percent $3s3p^2$, is found to have most of the ^2D absorption oscillator strength (f = 1.1). The general properties of this model of series perturbations are also discussed in some detail.

11183. Weiss, B-Z., Meyerson, M. R., **Localized microstructural changes and fatigue crack propagation,** *Trans. Met. Soc. AIME* **242,** 2515-2518 (1968).

Key words: Austenitic steels; carbide precipitation; fatigue crack propagation; plastic deformation; plastic zone size; temper embrittlement.

Changes of plastic zone size during fatigue crack propagation in fully reversed cyclic bending at constant load amplitude for conditions of plain strain were investigated by two different techniques. It appears that the rate of fatigue crack propagation cannot be expressed as a continuous simple function of plastic zone size. This was related to the anisotropic conditions of plastic deformation in the plastic zone preceding the crack. A theoretical-mathematical evaluation was formulated for fatigue crack propagation during repeated cyclic bending under conditions of plane strain. The theory is based on an elastic model and the assumption that the plastic deformation at the tip of the propagating crack does not cause drastic redistribution of stresses in the stress field around the tip of the crack. It was found that fatigue crack propagation can be expressed as a function of stress intensity factor.

Experimental results are in good agreement with the presented theoretical evaluation.

The effect of localized (heterogenous) structural changes such as selective precipitation of carbides in austenitic steels, temper embrittlement in a low alloy steel, and partial martensitic transformation in a metastable austenitic steel have been investigated and are discussed.

11184. Weiss, B-Z., Meyerson, M. R., **The effect of mean stress on fatigue crack propagation in plates under extension and bending,** *J. Basic Eng.* **90,** Series D, No. 3, 414-417 (Sept. 1968).

Key words: Crack propagation; fatigue; plastic zone.

This discussion presents comments on a paper by R. Roberts and F. Erdogan, "The Effect of Mean Stress on Fatigue Crack Propagation in Plates Under Extension and Bending." Some original data are presented to support the views of the discussers.

11185. Weissberg, S. G., Brown, J. E., **Osmometry of polymers,** *Encyclopedia of Polymer Science and Technology* **9,** 659-668 (Interscience Publs. Inc., New York, N.Y., 1969).

Key words: High speed osmometer; number-average molecular weight; osmometer; osmotic pressure; semipermeable membranes.

Brief summary of principles and methods of measurement of osmotic pressures of polymer solutions, with survey of modern high speed instruments.

11186. Weissler, P. G., **International standard reference zero for audiometers,** *J. Acoust. Soc. Am.* **44,** No. 1, 264-275 (July 1968).

Key words: Artificial ear; earphones; international audiometric reference zero; pure-tone audiometers; threshold of hearing; uncertainty of threshold of hearing standard.

This is a detailed report on the technical activities of ISO's Technical Committee on Acoustics No. 43, Working Group on Threshold of Hearing, which led to the ISO Recommendation R389, "Standard Reference Zero for the Calibration of Pure-Tone Audiometers," November 1964.

The activities described are the determinations of the transfer factors from loudness balancing experiments between the five earphone-coupler combinations in R389, the incorporation of the transfer data into the computation of the reference equivalent threshold sound pressure levels (RETSPL) in R389, and the details of the weighting of the original threshold determinations. A statistical analysis estimates the average standard deviation of the RETSPL in R389 to be 2 dB due in large part to the variance in the transfer factors. The present USASI standards are definitely outside the ISO uncertainty limits at all frequencies. The standard deviation of the differences between columns in R389, (or the equivalence of the RETSPL for the different earphone-coupler combinations) was estimated to be 2.5 dB. To improve accuracy in audiometry it is suggested that the variance due to the transfer factors be eliminated by agreement on one standard earphone type.

11187. West, E. D., Churney, K. L., **A two-body model for the calorimeters with constant-temperature environment,** *J. Appl. Phys.* **39,** No. 9, 4206-4215 (Aug. 1968).

Key words: Calorimeter; "drop" calorimeter; enthalpy measurements; heat content measurements; isoperibol calorimeter.

Equations are derived describing a model of a model of an isoperibol calorimeter in which the calorimeter proper consists of two parts thermally connected, one surrounding the other and exchanging heat with the constant temperature environment. These solutions provide insights into the behavior of real calorimeters. Inferences are drawn relative to the effect of the locations of the thermometer and heat source on the energy equivalent of the calorimeter and some possible errors are pointed out. Macleod's application of the two-body theory of King and Grover to high temperature enthalpy measurements is discussed and weaknesses in theory and experiment are pointed out. Procedures having a better theoretical basis are outlined.

11188. West, E. D., Westrum, E. F., Jr., **Adiabatic calorimetry from 300 to 800 K,** Chapter 9 in *Experimental Thermodynamics,* **Vol. I,** *Calorimetry of Nonreacting Systems,* J. P. McCullough and D. W. Scott, eds., pp. 333-367 (Butterworth and Co., London, England, 1968).

Key words: Adiabatic calorimetry; calorimeter; calorimetry; cryoscopy; melting; phase transition; purity; thermodynamics.

Adiabatic heat capacity calorimetry in the range 300 to 800 K is reviewed with discussions of principles and two particular calorimeters. The general heat flow problem is discussed qualitatively as it pertains to the design of calorimeters of this type. Construction details are included in the examples and related to the principles. The advantages and disadvantages of different methods of operation are discussed.

11189. Westrum, E. F., Jr., Furukawa, G. T., McCullough, J. P., **Adiabatic low-temperature calorimetry,** Chapter 5 in *Experimental Thermodynamics,* **Vol. I,** *Calorimetry of Nonreacting Systems,* J. P. McCullough and D. W. Scott, eds., pp. 133-214 (Butterworth and Co., London, England, 1968).

Key words: Adiabatic calorimetry; calorimeters; calorimetry; cryoscopy; cryostats; curvature correction; heat-leak correction; low temperature calorimetry; phase studies; phase transitions; power; premelting correction; purity; smoothing of observations; temperature; thermodynamic properties; thermodynamics; thermometry; time vaporization correction.

Adiabatic heat-capacity calorimetry in the range 4 to about 350 K is reviewed with discussions in principles of calorimeter design, measurements, and analysis of data obtained. Measurements of temperature, power, and time are discussed with critical analysis of expected accuracy of circuitry and equipment used. Methods for transferring samples into the calorimeter vessel and various heat treatments in the calorimeter prior to measurements are suggested for substances that undergo phase transitions. Procedures are given for heat-leak, premelting, curvature, and vaporization corrections. Methods for smoothing the observed heat-capacity data and calculation of thermodynamic properties are discussed.

11190. Wexler, A., **Calibration of humidity-measuring instruments at the National Bureau of Standards,** *ISA Trans.* **7,** No. 4, 356-362 (1968).

Key words: Calibration accuracies; gravimetric hygrometer; humidity calibration; humidity generator; hygrometry.

The National Bureau of Standards provides a service to Government agencies and the public for the calibration of humidity measuring instruments. The equipment and procedures employed in making these calibrations and the available ranges and accuracies are described. Calibrations are performed by subjecting the instrument under test to atmospheres of known moisture content produced by the NBS two-pressure humidity generator. The most accurate calibrations are made with the NBS standard hygrometer, a device based on the gravimetric method. With the latter, a measurement can be made with an estimated uncertainty (estimated systematic error plus three times the standard deviation) of 13 parts in 10^4.

11191. White, H. S., Jr., **Data management and standardization,** *Mod. Data* **2,** No. 5, 52-56 (May 1969).

Key words: Codes; data; data elements; data management; data standardization; information; information management; standardization.

A critical review is made of the current state of affairs as concerns the subject of data management and data standardization. A proposal is offered as an initial attempt to define a technique for the systematic management of data. The role of data standardization as a management tool is discussed. Various standardization efforts at the government, national, and international levels are described.

11192. Wiederhorn, S. M., **Fracture surface energy of glass,** *J. Am. Ceramic Soc.* **52,** No. 2, 99-105 (1969).

Key words: Cleavage; cohesive strength; cracks; double cantilever cleavage technique; fracture; fracture mechanics; glass; stress intensity factor; surface energy.

Fracture surface energies of six different glasses were measured using the double-cantilever cleavage technique. Values obtained ranged from 3.5 to 5.3 J/m^2 depending on the chemical composition of the glass and the temperature of the test. The fracture surface energy increased with decreasing temperature and increasing Young's modulus, however, exceptions to this behavior were noted. The magnitude of the values obtained are discussed with respect to the theoretical strength of glass, and possible irreversible effects at the crack tip such as stress corrosion and plastic deformation are considered.

11193. Wiederhorn, S. M., **Moisture assisted crack growth in ceramics,** *Intern. J. Fracture Mech.* **4,** No. 2, 171-177 (June 1968).

Key words: Ceramics; crack growth; delayed failure; fracture; glass; sapphire; static fatigue; stress corrosion.

A method is described to study subcritical crack growth in ceramic materials. Large, macroscopic size cracks were used and quantitative crack velocity measurements were made on glass and sapphire as a function of applied force, temperature and environment. The measured crack velocity was a complex function of stress and water vapor concentration in the environment and portions of the data could be adequately explained by the stress corrosion theory of Charles and Hillig.

11194. Wiese, W. L., **Dependence of atomic f-values on nuclear charge,** (Proc. Conf. Beam-Foil Spectroscopy, University of Arizona, Tucson, Arizona, Nov. 20-22, 1967), Chapter in *Beam Foil Spectroscopy* **II,** 386-406 (Gordon and Breach Science Publ. Inc., New York, N.Y., 1968).

Key words: Nuclear charge; oscillator strength; perturbation theory; systematic trend.

Conventional perturbation theory predicts a simple relationship between atomic oscillator strength and nuclear charge, which is rederived and discussed in some detail. By utilizing available f-value data for the lighter elements, it is then shown that this dependence is clearly evident in the numerical material supplied by theory as well as experiment. Several representative examples are given in graphical form and discussed.

11195. Wiese, W. L., **Systematic trends of atomic oscillator strengths in isoelectronic sequences,** *Appl. Opt.* **7,** No. 12, 2361-2366 (Dec. 1968).

Key words: Atomic oscillator strengths; beam foil spectroscopy; isoelectronic sequences; nuclear charge dependence; systematic trends.

The dependence of atomic oscillator strengths (f-values) on nuclear charge, which leads to systematic trends along isoelectronic sequences, is discussed with particular reference to beam foil spectroscopy. The theoretical background for the nuclear charge dependence is given first, and then several characteristic examples are reviewed in detail. The beam foil technique of measuring lifetimes is one of the most important data sources, because it readily permits reliable experimental determinations of f-values over several stages of ionization within isoelectronic sequences. It is shown that experimental data are most urgently needed when f-values are affected by cancellation in the transition integral or configuration interaction effects, since in these cases most theoretical approaches run into great difficulties.

11196. Wiese, W. L., Weiss, A. W., **Regularities in atomic oscillator strengths,** *Phys. Rev.* **175,** No. 1, 50-65 (Nov. 5, 1968).

Key words: Atomic oscillator strengths; atomic spectroscopy; isoelectronic sequences; spectral series; spectroscopic regularities.

Many regularities and systematic trends among atomic oscillator strengths have been studied using the extensive material which has recently become available for the lighter elements. The quantum mechanical background for the existence of these regularities is discussed, and in particular the relationship between oscillator strength and nuclear charge as predicted from conventional perturbation theory is reviewed in detail. A number of characteristic numerical examples are then presented. The regularities are of great practical importance since they may be exploited to obtain additional oscillator strengths by simple interpolation techniques as well as to evaluate the reliability of existing data by the degree of fit into established systematic trends.

11197. Wilcox, R. M., **Bounds for the isothermal, adiabatic, and isolated static susceptibility tensors,** *Phys. Rev.* **174,** No. 2, 624-629 (Oct. 10, 1968).

Key words: Bounds; dielectric; inequalities; magnetic; susceptibilities.

Quantum statistical proofs are given that: (1) the isolated (or Kubo) susceptibility tensor is positive indefinite and is bounded from above by the adiabatic susceptibility tensor; (2) the isothermal susceptibility tensor is positive definite and is bounded from below by the adiabatic susceptibility tensor. The results apply to either the static dielectric or magnetic cases. Biasing fields and permanent dipole moments may be present if desired. Criteria for equality of the various susceptibilities is established.

11198. Wildhack, W. A., **Improving measurement accuracy for high systems reliability,** *Electronics* **41,** No. 5, 280 (Mar. 4, 1968).

Key words: Accuracy; accuracy chart; calibration uncertainties; measurement; measurement systems; reliability; system reliability; uncertainty.

The accuracy actually attained in measurements, at any stage, may critically limit the actual reliability of an operational item or system, as well as the confidence in both predictions and demonstrations of performance and reliability. Measurement uncertainty increases with each successive echelon of calibration, with intervals between calibrations or checks, with environmental fluctuations, and with rigors of use in laboratory, plant or field. Available and developing resources and techniques for improving achieved accuracy in practical measurements are discussed.

11199. Wildhack, W. A., Mason, H. L., Powers, R. S., Jr., **Accuracy charts for RF measurements,** *Proc. IEEE* **55,** No. 6, 1056-1063 (June 1967).

Key words: Accuracy; calibration; IEEE; measurements; radio; radio frequency.

The general factors involved in the estimation of uncertainties in calibration or measurement are reviewed briefly. Twenty-five accuracy charts are presented showing the estimated uncertainties in National Bureau of Standards calibrations of laboratory standards or measuring instruments for electrical and radio frequency quantities.

11200. Williams, E. S., **A voltage converter for a new era,** *Meas. Data* **2,** No. 6, 75-79 (Nov.-Dec. 1968).

Key words: Emf comparator; frequency compensation; temperature compensation; thermoelement; transfer voltmeter; voltage converter.

A set of thermal voltage converters recently developed at NBS consists of five series resistor units and two thermoelements, each of which can be used with any one of the resistors. The thermoelements have rated currents of 2.5 and 5 mA. This arrangement permits each resistor to be used for two voltage ranges. The ac-dc difference or frequency influence of each range is less than 20 ppm at 50 kHz from 1 to 600 volts. Adjacent ranges can also be intercompared, so that all ranges can be evaluated relative to any one in only six steps. The thermoelements are compensated for temperature changes to reduce warm-up drift. Difficulties with reversed d-c differences in the thermoelements and power supply instability are minimized by the test procedure used and by the special emf comparators, which are also described.

11201. Wims, A. M., McIntyre, D., Hynne, F., **Coexistence curve for 3-methylpentane-nitroethane near the critical point,** *J. Chem. Phys.* **50,** No. 2, 616-620 (Jan. 15, 1969).

Key words: Coexistence curve; critical phenomena; densitometer; magnetic suspension; nitroethane; 3-methylpentane.

The coexistence curve for the liquid mixture 3-methylpentane-nitroethane has been obtained using a visual and a float technique. A detailed analysis of the data shows that the composition differences of the coexisting liquid phases are proportional to $(t_c\text{-}t)\beta$, where $\beta = 0.340$ with a standard deviation of 0.010. As a result of this analysis and an analysis of the earlier work of Rice and Zimm it is shown that the value of β for binary liquids is not significantly different from the value for gas-liquid systems.

11202. Wolcott, N. M., Falge, R. L., Jr., **Ferromagnetism of $CrBe_{12}$,** *Phys. Rev.* **171,** No. 2, 591-595 (July 10, 1968).

Key words: Curie point; ferromagnetism; magnetic moment; susceptibility.

The intermetallic compound $CrBe_{12}$ has been found to exhibit ferromagnetism. The ferromagnetic and paramagnetic Curie temperatures are in close agreement, each about 50 K. The spontaneous moment is 0.15 or 0.22 Bohr magnetons per chromium atom depending on the scheme assumed. In the paramagnetic temperature range, one finds an effective magneton number of 2.22 Bohr magnetons per chromium atom.

11203. Wolcott, N. M., Falge, R. L., Jr., Bennett, L. H., **NMR studies in paramagnetic and ferromagnetic $CrBe_{12}$,** *Phys. Rev. Letters* **21,** No. 8, 546-549 (Aug. 19, 1968).

Key words: Be; Cr; ferromagnetism; hyperfine fields; nuclear magnetic resonance; paramagnetism.

The occurrence of bulk ferromagnetism, with a Curie point of about 50 K, is verified for $CrBe_{12}$ by nuclear magnetic resonance experiments. The magnetic properties are explored by means of *conventional* high field NMR in the ferromagnetic as well as the paramagnetic state.

11204. Wolfe, W. C., **Field study of floor coverings,** *Flooring* **74,** No. 11, 52-58 (Nov. 1968).

Key words: Adhesion; floor coverings; orangic coatings; performance characteristics; specifications; wear.

The National Bureau of Standards has made observations of the performance of floor coverings in areas of severe exposure in Department of Defense installations and some civilian applications over a period of 13 years (1955-68). Valuable information on the adhesion of coatings and coverings to their substrates, on wear and other performance characteristics was obtained. This information has been used by Federal agencies in preparing specifications and in selecting materials for specific applications. However, it is evident that the incomplete observations were not adequate to properly evaluate the relative performance of the different systems. Therefore recommendations are made for better-controlled field observations leading to laboratory investigations.

11205. Wolfgang, R., Zare, R. N., Branscomb, L. M., **Chemical accelerators,** *Science* **162,** No. 3855, 818-822 (Nov. 15, 1968).

Key words: Chemical accelerators.

This is a brief account of a conference on chemical accelerators held at the University of Colorado March 28-29, 1968, supported by the Advanced Research Projects Agency.

11206. Unassigned.

11207. Yakowitz, H., Heinrich, K. F. J., **Inclusion identification by means of electron probe microanalysis,** *Metallography* **1,** No. 1, 55-78 (Sept. 1968).

Key words: Concentration mapping; electron probe microanalysis; experiment design; inclusion analysis; microscopy; quantitative data scanning.

Each stage in the analysis of inclusions by electron probe microanalysis is evaluated. These stages include experimental design and instrument operation, specimen preparation, element identification, element distribution mapping and quantitative data scanning. The use of signals other than x-rays for inclusion analysis is considered as well as the analysis of submicron inclusions. The approach taken assumes that microprobe analysis will be used in conjunction with careful optical microscopy and that quantitative microscopy may be used to classify the inclusions after microprobe analysis is carried out.

11208. Yonemura, G. T., Kasuya, M., **Color discrimination under reduced angular subtense and luminance,** *J. Opt. Soc. Am.* **59,** No. 2, 131-135 (Feb. 1969).

Key words: Color discrimination; signal lights; vision.

Under reduced visual conditions, small area and low luminance, color discrimination for normal eyes deteriorates in a manner similar to that observed for tritanopic vision. The purpose of this study was to investigate and quantify the reciprocal relation between area and luminance for conditions where this loss in color discrimination occurs for people with normal vision. Quadratic equations, $1n\ s = a(1n\ F)^2 + b(1n\ F) + C$, were obtained from the empirical data to describe the relationship between chromaticity discriminability s, with luminous flux F; where s = the standard deviation of color matches and $F = \omega^{3/4}L$ (target solid angular subtense ω, and luminance L). The constants a, b, and c are different for the red-green and blue-yellow directions on the chromaticity diagram. The results of this study find their most obvious application in the field of signal lights.

11209. Young, K. F., Forman, R. A., **Use of polystyrene beads for manufacture of low loss coaxial lines for low temperature research,** *Rev. Sci. Instr.* **39,** No. 12, 1964-1965 (Dec. 1968).

Key words: Coaxial cable; low-dielectric-loss coaxial lines; low temperature; transmission lines.

A new inexpensive technique is described for the production of experimental coaxial transmission lines for low temperature use. These lines have been tested in both nuclear quadrupole resonance and dielectric loss measurements and have proven to be as good electrically as commercial coaxial cable, with a large decrease in thermal conduction into the experimental system.

11210. Young, R. D., Kuyatt, C. E., **Resolution determination in field emission energy analyzers,** *Rev. Sci. Instr.* **39,** No. 10, 1477-1480 (Oct. 1968).

Key words: Analyzer resolution; energy analyzer; energy distribution; field emission.

The influence of energy analyzer transmission function on measured field emission energy distributions has been evaluated by folding a Gaussian transmission function into the field emission total-energy distribution. The resulting distributions at 0, 4.2, 20.3, 77, and 300 K are plotted as a function of the field- and work function-dependent parameter d, and for the special case $\varphi = 4.40$ eV, $F = 3.0 \times 10^7$ V/cm. A criterion is established for determining the width of an analyzer transmission function from distributions measured at the above temperatures. It is shown that the slope of the log of the energy distribution is changed by less than 1 percent when the analyzer width is changed from 0 to 100 mV.

11211. Zalubas, R., **Present state of analysis of the first spectrum of thorium (Th I),** *J. Opt. Soc. Am.* **58,** No. 9, 1195-1199 (Sept. 1968).

Key words: Energy levels Th I; first spectrum; thorium.

To date 268 even and 255 odd atomic energy levels in Th I have been found. The lowest level of the configuration $5f\ 6d\ 7s^2$ is $^3H_4^\circ$ and lies 7795.27 cm^{-1} above the ground level $^3F_2$ of $6d^2\ 7s^2$. Some levels of $5f\ 6d^2\ 7s$ and $6d^2\ 7s\ 7p$ are identified.

11212. Madey, T. E., Yates, J. T., Jr., **Desorption by electron impact: oxygen adsorbed on tungsten,** *Surface Sci.* **11,** No. 2, 327-351 (July 1968).

Key words: Binding states; chemisorption; cross section; desorption; electronic desorption; electron impact; oxygen; physisorption; tungsten.

The interaction of oxygen with a polycrystalline tungsten ribbon has been examined using electron stimulated desorption. At least three binding states of adsorbed oxygen have been identified: a physically adsorbed state which forms at 20 K, and two chemisorbed states designated β_1 and β_2. Both the physisorbed state and the β_1 state liberate positive ions when bombarded by 100 eV electrons; no positive ions were observed on electron bombardment of the β_2 state. The results indicate that the physisorbed state and the β_1 state are molecular. There is an enhanced adsorption of oxygen above 500 K which is primarily due to the creation of binding sites by thermal rearrangement of the oxygen covered surface. The maximum in the ion energy distribution is at 6.5 volts for β_1 oxygen and at 0.5 volts for physisorbed oxygen. The total cross section Q_{β_1} for electronic desorption from the β_1 state is 7×10^{-19} cm^2; the ionic cross section $Q_{\beta_1}^+$ is $\gtrsim 3.4 \times 10^{-20}$ cm^2. The maximum ion yields g^+ (ions/electron) are $g^+ = 1.5 \times 10^{-6}$ for 300 K adsorption, $g^+ = 3.3 \times 10^{-6}$ for adsorption at 730 K, and $g^+ = 5 \times 10^{-5}$ for adsorption at 20 K.

11213. Maki, A. G., **Comment on the Fermi resonance constant in ICN,** *J. Chem. Phys.* **50,** No. 5, 2273 (Mar. 1, 1969).

Key words: Energy levels; ICN; infrared spectroscopy; microwave spectroscopy; molecular structure; vibrational resonance.

From microwave data the value of the Fermi resonance constant for ICN is found to be $W_{12} = 35$ cm^{-1}. This is in fairly good agreement with the value of $W_{12} = 32.5$ cm^{-1} which was calculated from a harmonic internal-coordinate force field obtained using vibrational frequencies which were not corrected for anharmonicity.

11214. Manning, J. R., **Vacancy-wind effect in diffusion and deviations from thermodynamic equilibrium conditions,** *Can. J. Phys.* **46,** No. 23, 2633-2643 (1968).

Key words: Correlation factor; deviations from thermodynamic equilibrium; diffusion; distortions of vacancy flux; vacancy concentrations; vacancy flow; vacancy wind.

The vacancy flow (or "wind") term which appears in kinetic treatments of the diffusion equations is discussed in terms of the vacancy concentrations which appear when a vacancy flow is distorted by an impurity. It is pointed out that this term arises from local distortions in the vacancy concentration profile and not from any overall deviation of the material from equilibrium vacancy concentrations. Thus, the thermodynamic treatment of Kirkaldy and Lane does not include the vacancy wind term. Several physical analogies help to describe the basic process.

The vacancy wind effect arises from motion of atoms other than the particular diffusing atom. In addition, motion of the diffusing atom itself can introduce distortions in the local vacancy distribution. For a slow-diffusing impurity, mobile-impurity effects are unimportant; but, for a fast-diffusing impurity, they become very important, both in their effect on the diffusion equations and in their effect on local vacancy distributions. Equations are given for the resulting deviations from equilibrium at sites neighboring on an impurity. The close relationship between mobile-impurity effects and the correlation factor is shown. For self-diffusion, mobile-impurity and vacancy wind effects exactly cancel in their influence on vacancy distributions.

11215. Marinenko, G., Taylor, J. K., **Electrochemical equivalents of benzoic and oxalic acid,** *Anal. Chem.* **40,** No. 11, 1645-1651 (Sept. 1968).

Key words: Benzoic acid coulometer; electrochemical equivalent; faraday; oxalic acid coulometer.

Accurate values of the electrochemical equivalents of benzoic and oxalic acid dihydrate have been determined using a coulometer based on the electrochemical reaction $H^+ + e \rightarrow 1/2\ H_2$. The values of electrochemical equivalents of benzoic and oxalic acid dihydrate are 1.265715 ± 0.000036 mg/C and 0.653293 ± 0.000023 mg/C, respectively. The standards of electric current, mass, and time as maintained by the National Bureau of Standards were utilized in these determinations. The electric current was measured in terms of the emf of saturated Weston cells and electrical resistance. Benzoic acid ($99.995_5\%$ pure) and oxalic acid ($99.987_1\%$ pure) were used in this work. On the basis of these determinations, using the 1967 unified atomic weight scale, the faraday is calculated to be 96,486.7 ± 2.5 C/g-equiv. and 96,485.4 ± 3.4 C/g-equiv. for benzoic and oxalic acid coulometers, respectively. The indicated uncertainties are the overall limits of error based on the sum of the 95 percent confidence limits for the mean and an allowance for the effects of known sources of possible systematic error. It is proposed that conformance of material to its theoretical electrochemical equivalent should define the absolute purity and the faraday be used as the primary chemical standard of purity.

11216. Marzetta, L. A., **Noise limitations in signal detectors,** *Instr. Technol.* **16,** No. 2, 51-53 (Feb. 1969).

Key words: Low-frequency detector; noise power; noise temperature; operational amplifiers; thermal noise.

A vigorous development program pursued in recent years by industry has resulted in a number of interesting electropotential detectors. The large void in a performance plot of available signal amplifiers of yesteryear has been almost completely occupied by devices that in some cases approach the theoretical thermal-noise limit, over a signal source resistance range from 10^0 to 10^{16} ohms. There is good reason to expect the small remaining area marked for improvement will be filled in the near future.

11217. Matsumura, C., Lide, D. R., Jr., **Structure of the alkali hydroxides. III. Microwave spectra of RbOH and RbOD,** *J. Chem. Phys.* **50,** No. 1, 71-75 (Jan. 1, 1969).

Key words: Bond distances; high temperature; microwave; quadrupole; RbOH; rotational constants; spectra.

The microwave spectra of gaseous RbOH and RbOD have been measured with a high-temperature spectrometer. The spectra are generally similar to those observed in CsOH and indicate an essentially linear structure for rubidium hydroxide. The variation of rotational constant with excitation of the bending mode shows anomalies similar to those found in CsOH. The Rb—O bond length is found to be 2.30_5 Å. while the O—H distance is 0.96_5 Å. Analysis of the nuclear quadrupole hyperfine structure give eqQ values of −67.9 Mc/s in $Rb^{85}OH$ and −35 Mc/s in $Rb^{87}OH$.

11218. Mazur, J., McCrackin, F. L., **Monte Carlo studies of configurational and thermodynamic properties of self-interacting linear polymer chains,** *J. Chem. Phys.* **49,** No. 2, 648-665 (July 15, 1968).

Key words: Excluded volume; lattice; Monte Carlo; polymers; random walks; thermodynamics.

Non-self-intersecting walks on the simple cubic and face centered cubic lattices are used as a model for the linear polymer chain with excluded volume. The statistical properties of this model with nearest neighbor interactions between the chain elements are investigated by the Monte Carlo technique. The following properties are investigated: the limiting distribution function of chain-end dimensions, the dependence of mean square length of the chain on the number of chain elements, and the thermodynamic properties of the chain. A particular value for the nearest-neighbor interaction parameter was found which uniquely defines the Flory's theta point of the single chain. Evidence for the phase transitions in the infinitely long chain is also presented.

11219. Mazur, J., McIntyre, D., Wims, A. M., **Asymptotic behavior of the light-scattering function of coiled molecules,** *J. Chem. Phys.* **49,** No. 7, 2896-2904 (Oct. 1, 1968).

Key words: Chain-end distribution; excluded volume; light scattering; particle scattering factor; polydispersity.

This paper discusses the asymptotic solution of the scattering function $P(\Theta)$ for large x where x is proportional to the scattering angle, radius of gyration and the wave number. The theoretical model employed for the calculation of the $P(\Theta)$ vs. x curves was presented in the preceding paper. The results are discussed with respect to the experimental data, after the results for $P(\Theta)$ are corrected for various values of polydispersity.

A general analysis of the theoretical $P(\Theta)$ vs. x curves is presented, and the effect of the shape of the chain-end distribution function on the asymptotic behavior of the light scattering function is discussed.

11220. Mears, T. W., Young, D. S., **Measurement and standard reference materials in clinical chemistry,** *Am. J. Clin. Pathol.* **50,** No. 4, 411-421 (Oct. 1968).

Key words: Clinical; measurement; medicine; standard reference materials.

The concept of the measurement system based upon the four parameters—length (meter), mass (kilogram), time (second), and temperature (kelvin)—is developed. The proper daily operation of an analytical laboratory depends on these basic measurements, and several derived from them, e.g., the liter. An additional component of chemical measurement which directly influences accuracy is the purity of the standards and reagents employed. The Standard Reference Materials program of the National Bureau of Standards provides a central source of guaranteed high-purity reference materials which are available to all. The reliability of chemical measurements will increase as new Standard Reference Materials such as cholesterol, uric acid, urea, and creatinine are utilized to standardize methods and instruments in the clinical laboratories of this country.

11221. Mendlowitz, H., **Calculated line strengths for the transitions between the configurations ($3d^3+3d^24s$) and $3d^24p$ in Ti II,** *Astrophys. J.* **154,** 1099-1110 (Dec. 1968).

Key words: Calculated line strengths; configuration interaction; intermediate coupling; Ti II; $3d^3$; $3d^24s$; $3d^24p$ configurations.

We have calculated the relative line strengths in Ti II for the transitions between the configurations ($3d^3+3d^24s$) and $3d^24p$. The strengths have been calculated in the intermediate coupling scheme while also taking into account the interaction between configurations. The relative magnitude and phase of the radial transition integrals (s-p) and (d-p) for the jumping electron in the LS coupling scheme have been obtained empirically from the data of King and that of Wobig by means of a least-squares fit to each set of data separately. From both sets of data we determined the relative phase to be -1, and the ratio of the magnitudes of the radial integral parameters obtained from King's data differed from that obtained from Wobig's data by 10 percent. We have normalized the strengths in our paper to the absolute strengths of a group of lines corresponding to the transitions of the $a^4P - z^4D^0$ multiplet given by Wobig. A comparison of the calculated and experimentally determined line strengths are made. An analysis of the data indicates that a number of the experimentally determined lines are obtained under optically thick conditions.

11222. Meshkov, S., Ponzini, R., **$Su(6)_W$ and high-energy photoproduction,** *Phys. Rev.* **175,** No. 5, 2030-2034 (Nov. 25, 1968).

Key words: Dominance; meson; photoproduction-meson; $SU(6)_W$; symmetry; vector.

$SU(6)_W$ is used to make quantitative predictions for forward photoproduction cross sections at high energies. The predicted ratios for $\sigma(\gamma p|K^+\Sigma^0)/\sigma(\gamma p|K^+\Lambda)$ which vary from 0.5-1.0 for incident photons of energy 5-16 GeV are in good agreement with the SLAC experiments. This is in contrast to the quark model prediction of 1/27. Forward ρ^0p and ωp photoproduction cross sections also agree very well with experiment, but φp is too large by a factor of two.

11223. Meyerson, M. R., Giles, P. M., Newfeld, P. F., **Dimensional stability of gage block materials,** *J. Mater.* **3,** No. 4, 727-743 (1968).

Key words: Ceramic; cermets; dimensional stability; gage blocks; length standards; precipitation hardening steel; secondary hardening steel; tempering; through hardening steel.

Gage blocks which are necessary for the production of dimensionally precise items may undergo a change of dimensions with time. These changes are often extensive enough to cause the gage block to lose its value as a standard of length. This paper describes the program carried out at the National Bureau of Standards, Institute for Materials Research over the past eight years which has been successful in producing gage blocks which exhibit dimensional changes of less than $\pm 2\times 10^{-7}$ in./in./yr.

Studies have been made on the effect on long term dimensional stability of variation of thermal and mechanical processing procedures of gage blocks produced from four general categories of material. These four categories include (1) through hardened steels, (2) steels with hard cases and annealed cores, (3) steels with hard cases and partially hardened cores, and (4) ceramic and cermet materials.

11224. Mielenz, K. D., **Gas lasers and conventional sources in interferometry,** Chapter in *Electron Beam and Laser Beam Technology,* pp. 89-137 (Academic Press Inc., New York, N.Y., 1968).

Key words: Coherence; interferometers; lasers; light sources; multiple-beam; two-beam.

The theory of length interferometers is derived from the point of view of coherence theory. The performance of gas lasers and conventional sources in length interferometry is discussed.

11225. Mielenz, K. D., **Length measurement and laser wavelength stability,** *ISA Trans.* **6,** No. 4, 293-297 (1967).

Key words: Coherence; interferometry; lasers; length measurement; length standards; wavelength stability.

The application of gas lasers as light sources for interferometric length metrology, and the limitations imposed by variations of laser wavelengths, are discussed.

11226. Mies, F. H., **Configuration interaction theory. Effects of overlapping resonances,** *Phys. Rev.* **175,** No. 1, 164-175 (Nov. 5, 1968).

Key words: Autoionization; configuration interaction; electron scattering; photoionization; overlapping resonances; resonances; resonant scattering.

A generalized version of Fano's configuration interaction theory is presented which includes the interaction of many resonances with many continua and inelastic couplings between continuum states. In particular a new parameter is introduced; the overlap matrix between the continua to which neighboring resonances are coupled. Resonances which are coupled to the same channel states may be said to overlap. If their widths are comparable to their spacings the resultant effects on photoabsorption or on the scattering matrix can be quite profound. The apparent widths may bear little relation to the widths due to configuration interaction, and the resultant structure may not fit the usual Fano shapes for isolated resonances.

The effects of overlapping are examined for various models which are representative of atomic photoabsorption and electron-diatomic molecule scattering. It is demonstrated that without prior knowledge of the overlap matrix it is impossible to uniquely characterize a resonance from limited experimental observations. Scattering and photoabsorption experiments should be designed to examine all possible channels; both differential cross-sections and inelastic cross-sections. Even so, without the parallel support of theoretical estimates of partial widths, and the signs of the configuration interaction matrix elements, the interpretation of resonance phenomena and in particular the parameters which are extracted must be accepted with severe reservations.

11227. Mighell, A. D., Reimann, C. W., Mauer, F. A., **The crystal and molecular structure of diaquobis-(2,2′-biimidazole) nickel (II) dinitrate, $Ni(C_6H_6N_4)_2(H_2O)_2(NO_3)_2$,** *Acta Cryst.* **B25,** Part 1, 60-66 (Jan. 1969).

Key words: Biimidazole and water ligands; hydrogen bonding; transition metal coordination complex; x-ray structure determination.

The crystal and molecular structure of diaquobis(2,2′ biimidazole nickel (II) dinitrate, $Ni(C_6H_6N_4)_2(H_2O)_2(NO_3)_2$, was determined by single crystal x-ray diffraction techniques. This compound crystallizes in the monoclinic system with $a = 10.3925 \pm 0.0004$ Å, $b = 9.6284 \pm 0.0004$ Å, $c = 9.9615 \pm$

0.0003 Å, $\beta = 96.308 \pm 003$ Å, space group $P2_1/n$, $\rho_c = 1.68$ g cm^{-3}, and z = 2. The indicated uncertainties are the standard deviations of the sets of individual measurements involved. Three-dimensional data (3151 reflections) were used and the structure solved by the heavy atom method. The Ni(biimidazole)$_2$(H$_2$O)$_2$(NO$_3$)$_2$ molecule is centrosymmetric with the nickel atom at the center of an octahedron formed by two oxygen atoms and four nitrogen atoms. The four coordinating nitrogen atoms, two from each biimidazole molecule, form a rectangle (3.193 × 2.711 Å) and the water molecules lie above and below this plane. The structure consists of these complex cations linked by hydrogen bonds formed between coordinated water molecules, the noncoordinating nitrogen atoms in the biimidazole molecules and the nitrate anions.

11228. Mighell, A. D., Reimann, C. W., Santoro, A., **The crystal and molecule structure of dibromotetrapyrazole nickel(II), $Ni(C_3H_4N_2)_4Br_2$,** *Acta Cryst.* **B25,** Part 3, 595-599 (Mar. 1969).

> Key words: Coordination complex; tetragonal nickel(II); x-ray crystal structure.

The crystal and molecular structure of dibromotetrapyrazole nickel(II), $Ni(C_3H_4N_2)_4Br_2$, was determined by single crystal x-ray diffraction techniques. $Ni(C_3H_4N_2)_4Br_2$ crystallizes in the monoclinic system with a = 14.127 ± .007, b = 9.334 ± .003, c = 14.702 ± .002, b = 118.62 ± .03°, space group C2/c, p = 1.94 gm cm^{-3} and Z = 4. The structure was found to be isomorphous with dichlorotetrapyrazole nickel(II). The indicated uncertainties are the corresponding standard errors.

11229. Mighell, A. D., Smith, J. P., Brown, W. E., **The crystal structure of phosphoric acid hemihydrate, $H_3PO_4 \cdot 1/2H_2O$,** *Acta Cryst.* **25,** 776 (1969).

> Key words: Crystal structure; monoclinic crystals; phosphoric acid hemihydrate.

The crystal structure of phosphoric acid hemihydrate, $H_3PO_4 \cdot 1/2H_2O$, was determined from three-dimensional Weissenberg data. Its crystals are monoclinic, with a = 7.922 ± 0.010, b = 12.987 ± 0.02, c = 7.470 ± 0.010 Å, $\beta = 109.9 \pm 0.1°$, space group $P2_1/a$, and Z = 4. The structure was solved by vector methods and was then refined by full-matrix, isotropic, least-squares analysis. The two crystallographically independent phosphoric acid molecules are geometrically very similar to each other. Each is approximately tetrahedral with the P—O bond length significantly shorter than the P—OH bonds. Each phosphoryl oxygen atom, moreover, is the acceptor in two strong hydrogen bonds. The phosphoric acid and water molecules are linked into a three-dimensional network by hydrogen bonding, with each oxygen atom participating in at least one relatively strong intermolecular hydrogen bond.

11230. Miller, C. E., Lipsicas, M., **Nuclear spin-lattice relaxation in very dilute solutions of orthohydrogen in parahydrogen,** *Phys. Rev.* **176,** No. 1, 273-279 (Dec. 5, 1968).

> Key words: Nuclear magnetic resonance; ortho hydrogen; relaxation time.

Measurements have been made of the proton spin lattice relaxation time in very dilute solutions of orthohydrogen in parahydrogen, as a function of temperature, density and fractional orthohydrogen concentration. Both the liquid phase, between 20 and 32 K, and the gas phase, between 34 and 40 K, have been studied. The salient features of the temperature and density dependences, qualitatively, fit an interpretation in terms of contributions from two particle and three particle correlations, as proposed by Deutch and Oppenheim.

11231. Milligan, D. E., Jacox, M. E., **Matrix-isolation study of the reaction of F_2 and of F atoms with NCN. The infrared spectra of the species NF_2CN and FNCN,** *J. Chem. Phys.* **48,** No. 11, 4811-4816 (June 1, 1968).

> Key words: CF_2; CF_3; cyanogen azide; difluorocyanamide; F atom reaction; F_2 reaction; FNCN; infrared spectrum; isotopic substitution; matrix isolation; NCN reaction; photolysis.

NCN produced by the photolysis of cyanogen azide isolated in an Ar matrix at 14 K has been found to react readily with F_2 also present in the system, leading to the stabilization of NF_2CN. The absorption patterns observed for the most prominent infrared absorptions of $NF_2{}^{13}CN$ and of the two singly ^{15}N-substituted difluorocyanamides are consistent with the previous vibrational assignment. When both NCN and F atoms are present in appreciable concentration, absorptions appear at 873 and at 2068 cm^{-1} which may be tentatively assigned to the FNCN free radical. Upon prolonged photolysis, incompletely characterized products of more extensive fluorination reactions are observed.

11232. Milligan, D. E., Jacox, M. E., **Matrix-isolation study of the vacuum-ultraviolet photolysis of dichlorosilane. The infrared spectrum of the free radical $SiCl_2$,** *J. Chem. Phys.* **49,** No. 4, 1938-1942 (Aug. 15, 1968).

> Key words: Dichlorosilane; dichlorosilane-d_2; force constants; infrared spectrum; matrix isolation; photolysis; $SiCl_2$ free radical; ultraviolet spectrum.

In the studies of the vacuum-ultraviolet photolysis of SiH_2Cl_2 and of SiD_2CL_2 suspended in an argon matrix at 14 K, new absorptions appear at 502 and at 513 cm^{-1} which may be assigned as the two stretching fundamentals of $SiCl_2$. A broad, unstructured absorption is also observed in the region of the ultraviolet spectrum in which features tentatively ascribed to $SiCl_2$ were observed in earlier gas-phase emission studies. The detailed assignment of the observed infrared features is considered, and values of the valence angle, the Si-Cl stretching force constant, and the stretching-interaction force constant are estimated, corresponding to the two possible assignments for the infrared absorptions.

11233. Milligan, D. E., Jacox, M. E., **Matrix-isolation study of the vacuum-ultraviolet photolysis of difluorosilane. The infrared and ultraviolet spectra of the free radical SiF_2,** *J. Chem. Phys.* **49,** No. 10, 4269-4275 (Nov. 15, 1968).

> Key words: Difluorosilane; free radical; $HSiF_2$; infrared spectrum; matrix isolation; SiF_2; ultraviolet spectrum; vacuum-ultraviolet photolysis.

The vacuum-ultraviolet photolysis of difluorosilane in inert matrices at cryogenic temperatures has been found to lead to the stabilization of an appreciable concentration of SiF_2. A system of ultraviolet absorption bands observed in a neon matrix corresponds very well with the $0v_2'0$-000 bands recently reported for gas-phase SiF_2 produced by another technique. In an argon matrix the bending fundamental of SiF_2 appears at 343 cm^{-1} and the two stretching fundamentals at 843 and at 855 cm^{-1}. Evidence is presented supporting a previous assignment of these two fundamentals to the symmetric and antisymmetric stretching modes, respectively. Carbon monoxide matrix observations indicate that H-atom detachment plays an important role in the photolysis of difluorosilane. There is no evidence for the occurrence of processes involving F-atom detachment. It appears likely that an appreciable concentration of $HSiF_2$ is also stabilized in the present experiments.

11234. Milligan, D. E., Jacox, M. E., Guillory, W. A., **Matrix-isolation study of the vacuum-ultraviolet photolysis of trifluorosilane. The infrared spectrum of the free radical SiF_3,** *J. Chem. Phys.* **49,** No. 12, 5330-5335 (Dec. 15, 1968).

Key words: Force constants; infrared spectrum; matrix isolation; SiF_3 free radical; thermodynamic properties; trifluorosilane; ultraviolet spectrum; vacuum-ultraviolet photolysis.

In studies of the vacuum-ultraviolet photolysis of $SiHF_3$ suspended in argon, nitrogen, and carbon monoxide matrices at 14 K, evidence has been obtained indicating that H-atom detachment occurs and that the SiF_3 free radical is stabilized. All of the vibrational fundamentals of SiF_3 have been observed in these experiments. The appearance of two stretching fundamentals requires that the molecule be nonplanar. A more detailed consideration of the pattern of vibrational absorptions indicates that the angle between each Si-F bond and the threefold symmetry axis of the molecule is approximately 71°, close to the value characteristic of sp^3 hybridization of the valence electrons about the central atom. Force constants have been estimated using a four-constant valence-force potential, and the thermodynamic properties of SiF_3 have been calculated.

11235. Mills, R. M., **Flame inhibition with electron attachment as the first step,** *Combustion and Flame* **12,** No. 2, 513-520 (Dec. 1968).

Key words: Electron attachment; flame free radicals; flame inhibition mechanism.

The suggestion is made that combustion inhibition of the type observed with the use of most halogenated hydrocarbons is due to a two-step process: (1) negative ions and free radicals are formed by dissociative electron attachment with the inhibitor molecules, and then (2) these negative ions and/or free radicals react with the free radicals found in flames. Considerable evidence from the literature is presented which supports this idea. It is concluded that, while the evidence is not conclusive, a serious consideration of the idea is justified.

11236. Moore, C. E., **Annual report on spectroscopy,** *Bull. Am. Astron. Soc.* **1,** No. 1, 85-86 (Jan. 1969).

Key words: Analyses of optical spectra; atomic spectra; data centers; molecular spectra; rare earth spectra; transition probabilities.

The present report has been prepared especially for astrophysicists who are interested in the spectroscopic program at this Bureau. It is submitted annually and will be published with the Observatory Reports.

11237. Moore, G. A., **Application of computers to quantitative analysis of microstructures,** (Proc. Third Intern. Materials Symp., Berkeley, Calif., June 13, 1966), Chapter 3 in *Ceramic Microstructures,* R. M. Fulrath and J. A. Pask, eds., pp. 71-120 (John Wiley and Sons, Inc., New York, N.Y., 1968).

Key words: Analysis of microstructures; automatic scanning (of micrographs); computer processing (of micrographs); logical modification of pictures; precision scanning (of micrographs); quantitative microscopy.

The problems and methods of quantitative microscopy are basically identical in all microscopic sciences. Results are limited by the finite resolution of real micrographs and real observations and by the statistical necessity of processing a very large number of observations, thus dictating automatic scanning and computer processing methods.

The presence or absence of a specific phase can be represented by a two-dimensional binary array which can be rapidly processed to yield the required measurements. Logical modification by the computer is frequently necessary to substitute for some of the logical discriminations normally made by the human analyst and to facilitate the desired measurements.

Using high precision scanning equipment, the inaccuracies of measurement remain comparable to the limits imposed by statistics. Presently attainable precision is, however, an order of magnitude better than can normally be obtained by manual methods.

11238. Moore, G. A., Wyman, L. L., Joseph, H. M., **Comments on the possibilities of performing quantitative metallographic analyses with a digital computer,** Chapter 13 in *Quantitative Microscopy,* pp. 380-403 (McGraw-Hill Book Co. Inc., New York, N.Y., 1968).

Key words: Computer analysis of micrographs; grain size; micrographic analysis; pictorial analysis; quantitative microscopy; size distribution.

Preliminary experiments in the analysis of photographic information by means of a digital computer have shown that it is entirely feasible to analyze photomicrographs of metals by this means. The computer may be expected to become the quickest and most economical means of analysis whenever complete grain size or particle size distributions are to be obtained from 80 or more square inches of photomicrograph and when these distributions are to be translated into volume and weight terms.

11239. Mopsik, F. I., **Dielectric constant and loss,** *Digest of Literature on Dielectrics* **31,** 56-79 (1969).

Key words: Dielectric literature; dielectric literature in 1967; dielectric properties; digest of literature on dielectrics; literature compilation; survey of dielectric literature.

A compilation has been made of the literature appearing in 1967 on the subject of dielectric properties of materials. A summary of the highlights is included.

11240. Abramowitz, S., Levin, I. W., **Raman spectrum of ONF_3,** *J. Chem. Phys.* **51,** No. 1, 463-464 (July 1, 1969).

Key words: Infrared; laser; low temperature; Raman; trifluoramine oxide; vibrational assignment.

The Raman spectrum of a polycrystalline film of trifluoramine oxide at 78 K has been observed. The fundamental frequencies of the bending modes $\nu_3(A_1)$ and $\nu_5(E)$ are found at 535 and 522 cm^{-1}. The doubly degenerate NF_2 stretching mode, ν_4, is thought to be complicated by a resonance between ν_4 and $\nu_5 + \nu_6$.

11241. Allan, D. W., Guétrot, A., Higbie, L. S., Lavanceau, J. D., **An application of statistical smoothing techniques on VLF signals for comparison of time between USNO and NBS,** *Proc. 23rd Frequency Control Symp., Atlantic City, N.J., May 6-8, 1969,* p. 248 (1969).

Key words: Effect of mass on frequency; flicker noise; NBS; noise correlation; NSS; optimum filter; phase noise; radio propagation; time comparison; USNO; VLF propagation; WWVL.

Recent developments have provided a method for obtaining submicrosecond time comparisons over continental distances. The method was applied to a time comparison between the master clocks at the United States Naval Observatory (USNO) and at the National Bureau of Standards (NBS) in Boulder, Colorado.

There were the following developments. First, if two signals show a reasonable degree of correlation in their fluctuations, then one may derive an optimum linear combination of the two with a mean square error less than for either signal individually. The two signals studied were the transmissions on 21.4 kHz from NSS in Annapolis, Maryland, and on 20.0 kHz from WWVL in Fort Collins, Colorado. It is necessary that receivers be located for both signals at the locations of the controlling clocks. Existence of positive correlation was shown. The positive cross correlation probably was due to the near reciprocal path and the very close transmission frequencies.

Second, the phase fluctuations due to the propagation medium were consistent with a spectral density of the random phase noise proportional to $|f|^{-1}$, commonly called flicker of phase noise. This persisted for Fourier frequencies from one cycle per day down to one cycle per several weeks. The fluctuations on the linear combination of the two signals still behaved as flicker of phase noise but at a lower level.

The phase or time fluctuations of the master clocks however followed a spectral density law proportional to $|f|^{-3}$, flicker of frequency noise, for frequencies lower than one cycle per day.

Third, an optimum linear filter (Wiener filter) giving the minimum mean square error estimate (MMSEE) of the signal has been determined for a random walk of phase signal (spectral density proportional to $|f|^{-2}$) imbedded in white noise (spectral density proportional to $|f|^{0}$). The same filter was shown to be still optimum for spectral densities proportional to $|f|^{-3}$ for the signal and $|f|^{-1}$ for the noise.

Application of the above filter to the appropriate linear combination, defined through correlation properties, of NBS and WWVL signals showed an improvement of 15 dB in the rms day-to-day phase fluctuations. The day-to-day rms time deviations were about 70 ns on the final results. The output estimate of the filter, compared with portable clock measurements, gave a disparity of the order of the final output noise.

The experiment provided an opportunity to determine if there is an effect of mass on frequency and within the uncertainties of the experiment a null result was obtained.

11242. Alvarez, R., Paulsen, P. J., Kelleher, D. E., **Simultaneous determination of trace elements in platinum by isotope dilution and spark source mass spectrometry,** *Anal. Chem.* **41**, No. 7, 955-958 (June 1969).

Key words: Cation-exchange; electrodeposition; high-purity metal analysis; multi-element; spark source mass spectrometry; stable isotope dilution; trace determinations.

An isotope dilution technique using the spark source mass spectrograph was investigated for applicability to simultaneous, multi-element trace determinations. Isotopically altered Ag, Cu, Ni, Pb and Pd were separated from a 250-mg sample of platinum by cation exchange, and electrodeposited onto gold electrodes for sparking in the spectrograph. Electrodeposition provided the spiked analytes in an adherent form, relatively free of anions and organic residue from the ion exchange resin, both of which could complicate the spectrum. Contamination, the principal limitation of the method, was minimized by isothermally distilling the reagent acids and by isolating the operations from the laboratory environment. After determining the isotope ratios, the concentrations were computed, ranging from 0.5 ppm (μg/g) for Ni to 14 ppm for Pb. Improved precision and accuracy was obtained compared to conventional spark source analysis. The results were compared with those of other methods and the platinum material was issued by NBS as Standard Reference Material 681.

11243. Angeles, R., Aldridge, M., Freeman, D., Wall, L., **Cryodegradation of polyelectrolyte networks,** *Polymer Letters* 7, No. 8, 609-611 (1969).

Key words: Cryodegradation; freeze-thawing; polyelectrolyte networks; sulfonated polystyrene-divinylbenzene.

The cryodegradation of sulfonated polystyrene-divinylbenzene and the quaternary ammonium derivatives of the same copolymer was investigated by a swelling-ratio method. The results indicate that the networks swollen by water are extensively degraded by 150 freeze-thawing cycles. With these networks the effect of freeze-thawing is significantly greater than that observed with aqueously soluble linear sulfonated polystyrene.

11244. Armstrong, G. T., **Hydrogen fluoride and the thermochemistry of fluorine,** (Proc. Conf. Interagency Chemical Rocket Propulsion Group, Thermochemistry Working Group, Cleveland, Ohio, Apr. 9-11, 1969), *Seventh Meeting Bulletin* **1**, 119-135 (Chemical Propulsion Information Agency, Johns Hopkins University, Applied Physics Laboratory, Silver Spring, Maryland, Aug. 1969).

Key words: Fluorides, heat of formation; fluorine dissociation energy; fluorine thermochemistry; hydrofluoric acid; hydrogen fluoride.

The thermochemistry of hydrogen fluoride is reviewed. The principal emphasis is on the experimental basis of the heats of formation of HF(g) and of HF(aq). Data from flame calorimetry in which HF(g) and HF(aq) are formed, evidence from processes involving other fluorine compounds, and some evidence from spectroscopic and photodissociation studies are brought together.

11245. Armstrong, G. T., King, R. C., **The heats of formation of some fluorine-containing oxidizers,** (Proc. Conf. Interagency Chemical Rocket Propulsion Group, Thermochemistry Working Group, Cleveland, Ohio, Apr. 9-11, 1969), *Seventh Meeting Bulletin* **1**, 19-40, (Chemical Propulsion Information Agency, Johns Hopkins University, Applied Physics Laboratory, Silver Spring, Maryland, Aug. 1969).

Key words: Chlorine pentafluroide; chlorine trifluoride; Cl-F bond energy; flow calorimetry of gases; heats of formation of fluorine-containing oxidizers; hydrogen chloride; N-O bond energy; trifluoramine oxide.

A calorimetric apparatus previously developed for measuring enthalpy changes of constant pressure combustion reactions of corrosive, fluorine-containing materials and the enthalpy of solution of the acid products of combustion has been applied to the determination of the enthalpies of formation of chlorine trifluoride, chlorine pentafluoride, and trifluoramine oxide. The reactions of hydrogen with fluorine, chlorine, chlorine trifluoride, chlorine pentafluoride and trifluoramine oxide, followed by absorption of the HCl, HF, and H_2O formed in water or aqueous acid solution were studied. Preliminary values for the enthalpies of formation in kcal mol^{-1} are: $\Delta H_f[ClF_3(g)]$, -38.84 ± 0.5; $\Delta H_f[ClF_5(g)]$, -56.61 ± 1.0; and $\Delta H_f[NF_3O(g)]$, -44.67 ± 1.5, in which the uncertainties are our estimates of probable total systematic and random errors. The average Cl-F bond energy is 19.5 kcal mol^{-1} less in ClF_3 than in ClF and 5.5 kcal mol^{-1} less in ClF_5 than in ClF_3. The addition of an O atom to NF_3 to form NF_3O increases the binding energy by 74.4 kcal mol^{-1}.

11246. Astin, A. V., **Management and the metric system,** *Defense Management J.* **5**, No. 2, 27-34 (1969).

Key words: Accommodation; adaptation; conversion; customary units (U.S.); economic costs; interchangeability; international cooperation; metric system; SI units.

A decision on whether or not the United States will convert to the metric system may be facilitated by a current Congressionally-authorized study of the problem, described here by NBS Director Astin. Scientific, military, industrial, economic, trade, and educational considerations are discussed in detail, with illustrative material drawn from the experience of U.S. industries as well as those in foreign countries. Attention is focused on three kinds of interaction which would be involved in a metric changeover: accommodation, adaptation, and conversion.

11247. Bates, R. G., **Inner reference electrodes and their characteristics,** Chapter in *Glass Microelectrodes*, M. Lavallee, O. F.

Schanne, and N. C. Hebert, eds., pp. 1-24 (John Wiley and Sons, Inc., New York, N.Y., 1969).

Key words: Glass electrode; inner solutions; pH measurement calomel electrode; reference electrodes; temperature coefficients of e.m.f.; silver-silver chloride electrode.

The principles governing the selection of the most suitable electrodes and inner solutions for making electrical contact with the reference side of the glass electrode are set forth. Particular attention is given to choice of the best electrode and solution composition to minimize, or even to nullify, the temperature variation of the standard e.m.f. of the pH cell. Temperature coefficients of the e.m.f. of glass electrode pH cells of various designs are listed and other useful characteristics of inner electrodes and inner solutions are summarized.

11248. Bates, R. G., **Measurement of pH,** *Handbook of Biochemistry,* H. A. Sober, ed., pp. J190-J194 (Chemical Rubber Company, Cleveland, Ohio, 1967).

Key words: Acidity; glass electrode; indicators; pH; standardization.

The operational definition of pH, in the form endorsed by the International Union of Pure and Applied Chemistry, is presented. The preparation of standard reference solutions for pH measurements is described and the choice of electrodes and measurement techniques is discussed. The proper interpretation of pH numbers is set forth briefly, and procedures for pH measurement with indicators are described.

The revised version includes the addition of two new primary pH standards to tables 1 and 3, coefficients for calculating the temperature dependence of pH in table 2, and a collection of pH values for miscellaneous buffer solutions.

11249. Bates, R. G., **Medium effects and pH in nonaqueous solvents,** Chapter in *Solute-Solvent Interactions,* C. D. Ritchie and J. F. Coetzee, eds., pp. 45-96 (Marcel Dekker Inc., New York, N.Y., 1969).

Key words: Acidity; ion activity; medium effect; nonaqueous solvents; pH; thermodynamics.

The nature of acidity in nonaqueous solvents of various types is discussed and the implications of acid-base behavior on the feasibility of establishing useful scales for experimental pH and acidity measurement are considered. The Brønsted concept provides a useful approach to the quantitative expression of acid-base potential in many solvent media with some acidic or basic character but is of doubtful value in aprotic or inert solvents. A general scale of acidity or electrode potential applicable to more than one solvent requires a knowledge of the medium effect of the proton or the free energy of transfer of the proton from one solvent to another. Various methods of determining medium effects for ions are considered and shown to be inadequate at the present time. The role of dielectric constant and solvation phenomena in the medium effect are discussed, and suggestions are made for the practical measurement of acidity in deuterium oxide and alcohol-water solvents.

11250. Beatty, R. W., **Coaxial power, impedance and attenuation calibration at the National Bureau of Standards,** *Microwave J.* **11,** No. 5, 65-75 (May 1968).

Key words: Attenuation; calibration; coaxial; impedance; microwave; power; standards.

NBS calibration methods are described for coaxial power, impedance, and attenuation at microwave frequencies. Present and future NBS capabilities in these areas are discussed. An indication is given of the state of the art, how NBS arrives at its quoted limits of error, and how it develops confidence in its reference standards. Details of some measurement procedures are given and a list of references is given for those who wish more information.

11251. Beatty, R. W., Yates, B. C., **A graph of return loss versus frequency for quarter-wavelength short-circuited waveguide impedance standards,** *IEEE Trans. Microwave Theory Tech.* **MTT-17,** No. 5, 282-284 (May 1969).

Key words: Coaxial short-circuit; impedance standards; microwave; return loss; waveguide short-circuit.

Formulas and a graph are presented for determining return losses of microwave impedance standards consisting of quarter wavelength sections of short-circuited waveguide. Most standard sizes of coaxial line and rectangular waveguide are included on the graph, which covers a frequency range from 0.2 to 330 GHz. The graph is based upon a conductivity of 10^7 mho per meter. Values of return loss read from the graph must then be divided by the square root of the actual conductivity relative to the above value. A table of bulk conductivities of various metals is given.

11252. Bender, P. L., **Optical orientation experiments at Princeton,** Chapter in *Polarisation Matiere et Rayonnement, Volume Jubilaire en L'Honneur D'Alfred Kastler,* pp. 346-441 (Presses Universitaires de France, Paris, 1969).

Key words: Atomic collisions; atomic orientation; collisional disorientation; optical pumping; resonance fluorescence; sodium.

A brief historical review of early optical orientation experiments at Princeton is given in this article. *It contains no new technical information.*

11253. Bennett, H. S., **Ultrasonic attenuation in Heisenberg magnets,** *Phys. Rev.* **181,** No. 2, 978 (May 10, 1969).

Key words: Antiferromagnet; critical fluctuations; ferromagnet; Gd; Heisenberg magnet; MnF_2; $RbMnF_3$; ultrasonic attenuation.

The microscopic theory developed by H. S. Bennett and E. Pytte to treat ultrasonic attenuation in Heisenberg magnets overestimates the critical fluctuations. It is shown that much better agreement with experiment obtains when this fact is explicitly taken into account.

11254. Bennett, L. H., **"Charge transfer" in intermetallic compounds: Example—The sodium thallide structure,** Chapter in *Structural Developments in Alloy Phases,* B. C. Giessen, ed., Discussion 1, 41-44 (Plenum Press Inc., New York, N.Y., 1969).

Key words: Alloys; charge transfer; intermetallic compounds; ionic bond; metallic bond; sodium thallide.

It has been usual to speak of an ionic bond coexisting with the metallic bond in metals. NaTl was one of the earliest examples of such a description. It is pointed out that NaTl can be described by an energy band structure not requiring ionic bonding. The color of LiCd is discussed.

11255. Birmingham, B. W., Flynn, T. W., **Cryogenics in United States National Programs,** *Cryogenics* 9, No. 1, 3-10 (Feb. 1969).

Key words: Agriculture; compressed gases; conservation; cryogenics; education; health; national goals; space; transportation.

The object is to discuss a segment of the compressed gas industry, namely the cryogenic industry, and its relation to selected national programs, such as space, health, agriculture, transportation, conservation, and education.

11256. Boone, T. H., Skoda, L. F., Cullen, W. C., **Laboratory-field comparisons of built-up roofing membranes,** *Roofing Siding Insul. Mag.* **46,** No. 4, 28-33 (Apr. 1969).

Key words: Bituminous adhesive; bituminous built-up membranes; engineering properties; laboratory-field comparison; strength-thickness.

The values of breaking load, elongation and thermal expansion of nine bituminous built-up membranes prepared by roofing contractors under field conditions and by technicians in the laboratory were measured at subfreezing temperatures. The data indicated that the field-prepared specimens agreed favorably with laboratory-prepared specimens, although the samples from the field frequently reflected higher values for thermal-shock resistance than did their laboratory-prepared counterparts. The higher values were attributed to the smaller amounts of bitumen used between the piles of the field specimens. The results appeared to support the validity of the application of the "strength-thickness rule" to bituminous built-up membranes.

11257. Boyd, M. E., Larsen, S. Y., Kilpatrick, J. E., **Quantum mechanical second virial coefficient of a Lennard-Jones gas. Helium,** *J. Chem. Phys.* **50,** No. 9, 4034-4055 (May 1, 1969).

Key words: Equation of state; helium; Lennard-Jones gas exchange effects; quantum mechanics; second virial coefficient; Wigner-Kirkwood expansion.

The quantum mechanical second virial coefficients of Lennard-Jones He^3 and He^4 gases with the De Boer parameters have been obtained over the complete temperature range from near absolute zero to the classical region. A formalism separating the virial into direct (Boltzmann) and exchange (spin and quantum statistics) contributions has been employed. The calculation is based on phase shifts except at the very highest temperatures where a Wigner-Kirkwood method has been used. Examinations of the exchange term shows in detail the rapid suppression of the statistical effects with rising temperature, their contribution dropping to less than .001 cm^3 by 7 K (He^4). Comparison of the high temperature (Boltzmann) results with those obtained by a third order Wigner-Kirkwood expansion shows excellent agreement down to about 50 K for He^4 and 60° for He^3. The Wigner-Kirkwood expansion is shown to be unsuitable for determining the behavior of the exchange terms.

11258. Braun, W., Bass, A. M., Davis, D. D., Simmons, J. D., **Flash photolysis of carbon suboxide: absolute rate constants for reactions of $C(^3P)$ and $C(^1D)$ with H_2, N_2, CO, NO, O_2 and CH_4,** *Proc. Roy. Soc.* **A312,** 417-434 (1969).

Key words: Absolute rate constants; carbon suboxide; flash photolysis; primary processes; reactions $C(^3P)$, $C(^1D)$.

The vacuum ultraviolet flash photolysis of C_3O_2 in the 159.0 nm absorption band has been investigated. The major primary products are $C(^1S)$, $C(^1D)$, $C(^3P)$, and CO. The species C_2 and C_3 have also been observed but are of minor importance in the overall reaction scheme. A number of pressure independent reactions involving $C(^3P)$, $C(^1D)$, and $C(^1S)$ with CO, CH_4, N_2, NO, O_2, and H_2 have been observed by means of the kinetic-spectroscopic method. The rate constants measured at room temperature in units of $cm^3\ sec^{-1} molec^{-1}$ are summarized here:

(7)	$C(^3P) + CH_4 \rightarrow C_2H_4$ (?);	$k < 5 \times 10^{-15}$
(8)	$C(^1D) + CH_4 \rightarrow C_2H_2 + H_2$;	$k = 3.2 \times 10^{-11}$
(10)	$C(^1D) + N_2 \rightarrow C(^3P) + N_2$;	$k \approx 2.5 \times 10^{-12}$
(12)	$C(^3P) + NO \rightarrow CN + O$;	$k = 1.1 \times 10^{-10}$
(13)	$C(^1D) + NO \rightarrow CN + O$;	$k = 9.2 \times 10^{-11}$
(18)	$C(^1D) + H_2 \rightarrow CH + H$;	$k = 4.15 \times 10^{-11}$
(19)	$C(^1S) + H_2 \rightarrow CH + H$ (?);	$k < 5 \times 10^{-12}$
(20)	$C(^3P) + O_2 \rightarrow CO + O$;	$k = 3.3 \times 10^{-11}$
(22)	$C(^1D) + O_2 \rightarrow CO + O$ (?);	$k < 5 \times 10^{-12}$

The pressure dependent reaction rates of $C(^3P)$ with N_2, CO, and H_2 have been qualitatively measured and are discussed in detail.

11259. Brennan, J. A., Edmonds, D. K., Smith, R. V., **Two-phase (liquid-vapor), mass-limiting flow with hydrogen and nitrogen,** (Proc. 1968 Cryogenic Engineering Conf., Case Western Reserve Univ., Cleveland, Ohio, Aug. 19-21, 1968), Chapter in *Advances in Cryogenic Engineering* **14,** Paper G-6, 294-298 (Plenum Press Inc., New York, N.Y., 1969).

Key words: Choking; critical; hydrogen; nitrogen; two-phase flow.

Experimental data on choked or mass-limiting flow at the exit of a constant area test section are presented. The data are compared to some simple analytical models which have been recommended to indicate upper and lower limits of the flow rates.

11260. Brower, W. S., Robbins, C. R., **Growth of $CaTiSiO_5$ by the Czochralski method,** *J. Crystal Growth* **5,** 233-234 (1969).

Key words: $CaTiSiO_5$; crystal growth; Czochralski method; single crystals.

Crystals of $CaTiSiO_5$ suitable for physical property measurements have been grown by the Czochralski method. Best results were obtained with relatively high rotation rates (100-150 rpm) and a linear growth rate of 0.15 cm/hr. The crystals are monoclinic with space group $P2_1/n$, the symmetry previously observed for anhydrous synthetic $CaTiSiO_5$, as compared with space group $C2/c$ reported for natural sphene (titanite) minerals of general formula $CaTiSiO_4$ (O, OH, F).

11261. Brown, J. E., Tryon, M., Horowitz, E., **Thermal decomposition of Cu(II)-bis(8-hydroxy-5-quinolyl) methane coordination polymer,** *J. Appl. Poly. Sci.* **13,** 1937-1947 (1969).

Key words: Bis(8-hydroxy-5-quinolyl)methane; coordination; copper; decomposition; infrared spectrophotometry; ligand; mass spectrometry; polymer; thermal; 8-hydroxyquinoline.

The volatile products formed when the coordination polymer of copper(II) and bis(8-hydroxy-5-quinolyl)methane was heated in vacuum at elevated preselected temperatures were examined. The amount of weight loss at each temperature was determined with a recording thermal balance. Infrared spectrophotometry was used to aid in the identification of the major volatile component. A sample was pyrolyzed directly into the mass spectrometer. The results show that the volatile product is for the most part the organic ligand, bis(8-hydroxy-5-quinolyl)methane and not derivatives of the copper complex or fragments of the ligand. The mechanism for the decomposition reaction previously proposed is supported.

11262. Bur, A. J., Roberts, D. E., **Rodlike and random-coil behavior of poly(n-butyl isocyanate) in dilute solution,** *J. Chem. Phys.* **51,** No. 1, 406-420 (July 1. 1969).

Key words: Dielectric constant; dielectric relaxation time; dipole moment; Kratky-Porod worm-like model; molecular relaxation in dilute solution; poly(butyl-isocyanate); polymer chain configuration; polypeptides; rodlike molecules.

The polymer chain configuration, molecular relaxation and the dipole moment of poly(n-butyl isocyanate), $(\text{-CO-NR-})_n$ where $R = C_4H_9$, have been studied by dielectric measurements of the polymer in dilute solution. The complex dielectric constant, $\epsilon^* = \epsilon' - j\epsilon''$, was measured at room temperature over a frequency range 10^{-1} Hz to 1×10^6 Hz for fractionated samples whose molecular weights cover a very broad range, 20×10^3 to 10×10^6. From observation of the dielectric relaxation time as a function of molecular weight we deduce that the low molecular weight molecule ($M_w < 80 \times 10^3$) is rodlike and helical. Upon increasing the molecular weight, this rodlike conformation can not be sustained and chain flexibility accumulates with the addition of each monomer unit to the chain. Finally at high molecular weight, $M_w > 10^6$, the polymer chain configuration can be described as random coil. The relaxation time and dipole moment measurements indicate that there is a one-to-one correspondence between the end-to-end distance and the dipole moment of the poly(n-butyl isocyanate) (PBIC)s molecule. Using the dipole moment data alone, we are able to show that the PBIC chain configuration as a function of molecular weight can be described by the Kratky-Porod worm-like model. The relationship between PBIC and biological molecules, especially the polypeptides, is discussed.

11263. Burke, P. G., Cooper, J. W., Ormonde, S., **Low energy scattering of electrons by helium,** *Phys. Rev.* **183,** No. 1, 245-264 (July 5, 1969).

Key words: Close coupling; eigenphase; electron helium scattering; excitation; polarization; resonance.

The close coupling equations for electron-helium scattering have been solved in the energy range near the n = 2 thresholds. Cross sections for elastic scattering from both ground and excited states, for excitation of the ground state to the n = 2 states (2^3S, 2^1S, 2^3P and 2^1P) and for excitation and de-excitation processes involving only the n = 2 levels are presented and compared with experimental evidence on total metastable production, on angular distributions of excitation cross sections to the n = 2 levels and on processes involving only the n = 2 states. The percentage polarization of light emitted by electron impact excitation to the 2^3P and 2^1P states is computed and compared with experiment. The calculations indicate the importance of resonances in near threshold excitation and de-excitation processes in He. An attempt has been made to understand the resonant structure by considering both the energy dependence of the eigenphases of the many-channel S matrix produced by solving the close coupling equations and the energy dependence of eigenvalues of the related time delay matrix.

11264. Butterfield, M. A., **OCR standards today,** Chapter 37 in *Optical Character Recognition and the Years Ahead,* pp. 318-335 (Business Press. Elmhurst, Ill., July 1969).

Key words: Information processing standards; ISO DR966 OCR character sets National Bureau of Standards; OCR; OCR-A character set; OCR-B character set; OCR character sets; OCR forms; OCR paper; optical character recognition; USASI X3.1.

Standards are agreed upon solutions to recurring problems. Character reading devices contain the five basic components for Paper Handling, Scanner Unit, Recognition Unit, Control Unit, and Output Unit. The requirements of paper handling and scanning define the mechanical properties and optical properties required in OCR paper and the reflective or non-reflective inks used to produce OCR forms.

Forms used in OCR systems are categorized as Journal Tapes, Documents or Pages. Character sets have been tentatively categorized by the USASI X3.1 Committee into four groups of zero, one, two, or three dimension properties. Typical OCR character sets in use include among others the Perry Publishing Co., Farrington 12L/12F, IBM 1401, IBM 1428, NCR NOF, OCR-B, and OCR-A Character Sets.

Current OCR standards work programs at the National Bureau of Standards are described along with reasons therefor. Organizations active in USA national and international ADP standards efforts are described.

11265. Cahill, K. E., **Regularization of the P representation,** *Phys. Rev.* **180,** No. 5. 1244-1255 (Apr. 25, 1969).

Key words: Density operator; electromagnetic field; P representation.

A representation is introduced for the density operator of the electromagnetic field that is suitable for all density operators and that reduces to the coherent-state P representation when the latter exists. It expresses the density operator ρ as the sum of four terms, each of which is a two-dimensional weighted integral over outer products of coherent states. The first integral has the form of the P representation, i.e., the outer products are project operators. The absence of singularities in this term is achieved by the presence of the three supplementary integrals which vanish when the density operator possesses the P representation. In general, for stationary density operators only the first two terms of the regularized P representation are necessary.

A simple prescription is given for obtaining the four weight functions of this representation from the function $\langle \alpha|\rho|\alpha \rangle$, where $|\alpha\rangle$ is a coherent state and ρ the density operator. According to this prescription, the P representation does not exist and one or more of the supplementary, regularizing terms is necessary when the function $\langle \alpha|\rho|\alpha \rangle$ contains a term that decreases more rapidly than $\exp(-|\alpha|^2)$ as $|\alpha| \rightarrow \infty$. The regularized P representation affords non-singular integral expressions for all density operators and for most expectation values, including, when they are finite, those of the normally ordered products of the creation and annihilation operators α and α^+. The construction and use of this representation is illustrated with the aid of simple examples in which the density operator does not possess the P representation.

11266. Carpenter, B. S., Cheek, C. H., **Trace determination of uranium in biological material by fission track counting,** *Anal. Chem.* **42,** No. 1, 121-123 (Jan. 1970).

Key words: Activation analysis; biological material; fission track; microanalysis; nuclear track; uranium.

The nuclear track technique for determining micro quantities of uranium in material, which consists of counting fission tracks produced in solid-state detectors as a result of neutron irradiation, is employed to determine trace quantities of uranium in such biological materials as mammalian blood and plasma and oak leaves. Dry-ashed samples of the material are dissolved in dilute acid and made up to standard volumes. Aliquots of these solutions are placed on Lexan polycarbonate detectors, evaporated to dryness, and enclosed in polyethylene bags. After irradiation in a thermal neutron flux, the bag is removed and the Lexan detectors are etched in a sodium hydroxide solution. The amount of uranium present in the biological matrices is determined by counting the etched fission tracks with an optical microscope and comparing the results with those obtained for simultaneously irradiated reference standards containing known amounts of uranium. Average results obtained from thermal neutron irradiations for the blood and plasma samples were 86.1 ppb and 60.5 ppb, respectively, while the values for oak leaves ranged from 1.62 to 15.2 ppm.

11267. Carroll, J. J., Melmed, A. J., **Ellipsometry-LEED study of the adsorption of oxygen on (011) tungsten,** *Surface Sci.* **16,** 251-264 (Aug. 1969).

Key words: Ellipsometry; low-energy-electron-diffraction; optical constants; oxidation of tungsten.

The direct combination of ellipsometry and low-energy-diffraction (LEED) techniques has been extended to a study of room temperature oxygen adsorption on (011) tungsten. It is shown that, by use of a special continuous data-taking method, ellipsometry is easily capable of detecting small fractions of a monolayer of adsorbed oxygen on this metal crystal face. From the partial correlation of LEED and ellipsometry data, average sticking probability for oxygen adsorption in the first 1/2 monolayer of atoms is deduced to be 0.2 or 0.4. depending on the choice of adsorption model.

The experimental ellipsometry results are not understandable in detail in terms of existing ellipsometry theory. Consequently, and in view of the LEED results, it is tentatively concluded that the present results support a previously published complicated adsorption model involving oxygen atom-tungsten atom rearrangements.

11268. Champion, C. E., Marinenko, G., **Errors in coulometric chloride titrations due to photodecomposition of silver chloride,** *Anal. Chem.* **41,** No. 1, 205-207 (Jan. 1969).

> Key words: Coulometric titration; high accuracy analysis; high precision analysis; photodecomposition; silver chloride.

Photodecomposition of silver chloride is a significant source of error in high accuracy argentimetric coulometry. A potentiometric method is described for the determination of the rate of photodecomposition under the conditions of a specific experiment. In a typical analysis, an initial rate of 0.5 μeq/hr was found which introduced an error of 0.02 percent in the coulometric analysis of a 2-meq sample during a titration period of one hour. A cubic equation, fitted to the rate data, was found to provide corrections for the photodecomposition effect with an accuracy of about 0.005 percent. However, to obtain an accuracy of the order of 0.001 percent it is necessary to exclude light from the coulometric titration cell.

11269. Colwell, J. H., **Molecular reorientation and nuclear spin conversion in the solid deuteromethanes at low temperature,** *J. Chem. Phys.* **51,** No. 9, 3820-3832 (Nov. 1, 1969).

> Key words: CD_4; CHD_3; CH_3D; CH_2D_2; heat capacity; heat capacity anomaly; residual entropy; zero-point entropy.

The heat capacities of the solid deuteromethanes have been measured down to 0.3 K, tracing out the low temperature heat capacity anomalies which had been detected in the earlier work of Colwell, Gill, and Morrison. The anomalies in CH_3D and CHD_3 have maxima at 0.43 and 0.48 K respectively, but the CH_2D_2 heat capacity is still increasing with decreasing temperature at 0.3 K. A small anomaly was found in CD_4 but this is ascribed to chemical and isotopic impurities present in the sample.

The observed anomalies are attributed to the removal of the orientational degeneracies of the molecules on the lattice sites which give rise to the well known residual entropies of Rln4 in CH_3D and CHD_3 and Rln6 in CH_2D_2. Nuclear spin conversion also occurs in CH_3D. This is substantiated by the measured entropy change of $\Delta S = 1.614R$ over the range 0.3 to 4 K which exceeds the maximum value of Rln4 (1.386R) for molecular reorientation occurring separately. The occurrence of conversion was also indicated by a slow process characterized by a relaxation time ranging from 75 to 35 seconds in going from 0.3 to 4 K. There was no indication of conversion occurring in either CH_2D_2 or CHD_3.

The heat capacity anomalies are of the Schottky form and the results have been analysed on the basis that the energy levels available to the molecules are independent of the extent of order in the system. Precise values of the energy level splittings are obtained for CH_3D and CHD_3, but there is some ambiguity as to which symmetry species the rotational states in CH_3D belong. Poor agreement between the calculated heat capacity and the observed anomaly in CH_2D_2 is taken as an indication that there may be cooperative effects occurring in this transition.

11270. Colwell, J. H., **The performance of a mechanical heat switch at low temperatures,** *Rev. Sci. Instr.* **40,** No. 9, 1182-1186 (Sept. 1969).

> Key words: Low temperature; low temperature calorimetry; mechanical heat switch; pressed contacts; thermal conductance of contacts; ^{3}He cryostat.

A mechanical heat switch used in calorimetry experiments down to 0.3 K is described and its performance analyzed in sufficient detail to be useful for design purposes. The thermal conductance of the indium-copper switch contacts was determined as a function of applied force and temperature over the range 0.3 to 2 K. These results are compared with other conductance measurements to evaluate choices of materials for heat switch contacts.

11271. Colwell, J. H., Mangum, B. W., Utton, D. B., **The low temperature magnetic properties of some hexagonal rare-earth trihalides,** *Phys. Rev.* **181,** No. 2, 842-854 (May 10, 1969).

> Key words: Heat capacity; linear chain models; low temperature; magnetic properties; magnetic susceptibility; nuclear quadrupole resonance; rare-earth trihalides; spontaneous magnetization.

We have made measurements of the low temperature heat capacity, magnetic susceptibility, and chlorine nuclear quadrupole resonance (NQR) of $CeCl_3$, $PrCl_3$, $NdCl_3$, $SmCl_3$ and $CeBr_3$. Some measurements have been made on $PrBr_3$ and $NdBr_3$. The experimental results can be closely correlated with antiferromagnetic linear chain models. The NQR shows that long-range order occurs in $PrCl_3$ at 0.428 K. In $NdCl_3$ the NQR line disappeared at 0.50 K and the resonances produced by an internal field appeared at 0.17 K. In $CeCl_3$ the NQR resonance disappeared at 0.110 K. In $CeCl_3$ the NQR resonance disappeared at 0.110 K and no lines were found above 0.054 K. In $SmCl_3$ the NQR line disappeared at 0.21 K and no resonance was observed above 0.1 K. In $PrCl_3$ and $NdCl_3$ we have measured the internal field, which is proportional to the sublattice magnetization, at the chlorine nucleus below their Néel temperatures and have determined the magnitude and the direction of the internal field at the chlorine nucleus relative to the principal axes of the electric field gradient.

11272. Cook, A. R., Matarrese, L. M., **Zero-field EPR of Fe^{3+} in quartz,** *J. Chem. Phys.* **50,** No. 6, 2361-2364 (Mar. 15, 1969).

> Key words: Amethyst; ferric ion; iron-doped quartz; synthetic brown quartz; zero-field EPR.

The zero-field EPR transition frequencies of Fe^{3+} in synthetic brown quartz (SBQ) and natural amethyst (NA) have been measured directly. The values obtained, 7113.2 ± 0.2 and 8812.5 ± 0.2 MHz for SBQ, and 24157.5 ± 0.5 and 35365 ± 2 MHz for NA, are in excellent agreement with those calculated from the spin Hamiltonians derived from ordinary high-field EPR spectroscopy.

11273. Cooper, M. J., Vicentini-Missoni, M., Joseph, R. I., **Linear parameterization of the equation of state near the critical point,** *Phys. Rev. Letters* **23,** No. 2, 70-73 (July 14, 1969).

> Key words: Critical point; equation of state; scaling laws; Schofield parameterization.

A linear parameterization of the equation of state near the critical point proposed by Schofield is tested. We find the available experimental data in the critical regions of a number of magnets ($CrBr_3$, Ni, Gd) and fluids (Co_2, Xe, He^4) is *not* generally consistent with an assumption of linearity. Agreement with such a linear form can be obtained only by locating the critical isochore asymptotically close to the coexistence line.

11274. Coriell, S. R., Hardy, S. C., **Morphology of unstable ice cylinders,** *J. Appl. Phys.* **40,** No. 4, 1652-1655 (Mar. 1969).

> Key words: Crystal growth; cylinder; ice; morphological stability; morphology; water.

The wavelengths of sinusoidal perturbations in the shape of ice cylinders growing in supercooled water have been measured as a function of the experimental variables, primarily bath supercooling. The experimental results are in good agreement with theory.

11275. Coxon, B., **Studies of ^{15}N-labeled aminosugars. Synthesis and spectroscopy of derivatives of 6-amino-6-deoxy-D-glucose-6-^{15}N,** *Carbohydrate Res.* **11,** 153-155 (1969).

Key words: Mass spectroscopy; N.M.R. spectroscopy; 6-amino-6-deoxy-D-glucose-^{15}N; ^{15}N-labeled aminosugars.

Derivatives of 6-amino-6-deoxy-D-glucose-^{15}N (or-^{14}N) have been synthesized by reaction of 1,2:3,5-di-*O*-isopropylidene-6-*O*-tolylsulfonyl-α-D-glucofuranose or 6-deoxy-6-iodo-1,2:3,5-di-*O*-isopropylidene-α-D-glucofuranose with potassium phthalimide-^{15}N (or-^{14}N) in *N,N*-dimethylformamide or hexamethylphosphoramide. The amino sugar derivatives have been studied by nuclear magnetic resonance and mass spectroscopy.

11276. Crawford, B. H., Nimeroff, I., **Radiation sources and their power supplies,** Chapter in *Techniques of Photostimulation in Biology,* (North-Holland Publ. Co., Amsterdam, Holland) pp. 19-48 (1968).

Key words: Photostimulation; power supplies; radiation.

11277. Crawford, M. L., **A new RF-DC substitution calorimeter with automatically controlled reference power,** *IEEE Trans. Instr. Meas.* **IM-17,** No. 4, 378-384 (Dec. 1968).

Key words: Coaxial dry-load calorimeter; feed-back control; radio-frequency power.

A new dual-dry-load calorimeter, incorporating automatically controlled reference dc input power, has been developed at the National Bureau of Standards. The calorimeter will be used as a reference standard at frequencies up to 4.0 GHz in the power range, 10 mW to 1 W. The maximum measurement uncertainty is 0.26 percent at frequencies below 1 GHz and 0.35 percent at frequencies above 1 GHz. The time required for the measurement system to reach equilibrium is less than two minutes. Construction details and design of the calorimetric and feedback control system are given along with an error analysis and results of intercomparisons with other standards.

11278. Crissman, J. M., **Mechanical relaxation in polypropylene as a function of polymorphism and degree of lamellar orientation,** *J. Poly. Sci.* **7,** Part A2, 389-404 (1969).

Key words: Isotactic polypropylene; mechanical relaxation; oriented lamella; torsion pendulum; α-modification; β-modification.

Mechanical relaxation data as a function of temperature ($\simeq$ 1Hz) have been obtained for several samples of isotactic polypropylene crystallized from the melt, which exhibit both α- and β-forms as well as varying degrees of lamella orientation. The samples ranged in morphology from an unoriented sample showing only the α-form to one highly oriented having approximately 90 percent the β-form. Results for the logarithmic decrement (Δ) and loss modulus (G'') indicate that the low temperature ($\simeq -75$ °C) and glass temperature ($\simeq 0$ °C) relaxations show little or no sensitivity to orientation in the α-form, but that the intensity of the two processes is different in the α-form than in the β-form for samples of nearly equal overall percent crystallinity. In both Δ and G'', the low temperature peak decreased and the glass-temperature peak increased in intensity as the fraction of β-form crystallinity present increased. Data for the high-temperature relaxation ($\simeq 80$ °C) indicate a dependence upon orientation and/or crystal form in addition to a dependence upon percent crystallinity.

11279. Cushen, W. E., **Systems analysis activities at the Technical Analysis Division of the National Bureau of Standards,** *C-E Newsletter* **4,** No. 3, 4-5 (June 1969).

Key words: Cost-effectiveness; systems analysis; Technical Analysis Division.

A general summary of the work of the Technical Analysis Division of the National Bureau of Standards is presented, with special emphasis on its studies in cost-effectiveness analysis. One of the novel studies now being initiated is the cost-effectiveness analysis of systems analysis studies; 12 kinds of needs in government are listed.

11280. Daney, D. E., Ludtke, P. E., Sindt, C. F., **Slush hydrogen pumping characteristics using a centrifugal-type pump,** (Proc. 1968 Cryogenic Engineering Conf., Case Western Reserve Univ., Cleveland, Ohio, Aug. 19-21, 1968), Chapter in *Advances in Cryogenic Engineering* **14,** Paper J-2, 438-445 (Plenum Press Inc., New York, N.Y., 1969).

Key words: Cavitation; centrifugal pumps; cryogenic pump; liquid-solid hydrogen mixtures; slush hydrogen.

The pumping characteristics of liquid-solid mixtures of parahydrogen (slush hydrogen) were investigated using a centrifugal type liquid hydrogen pump with a design specific speed of approximately 2200. Performance tests from 8,000 to 19,000 rpm and cavitation tests at 11,000 and 14,000 rpm were made. The slush solid fraction varied from 0.19 to 0.55. As predicted by theory, the developed head for liquid and slush hydrogen are the same when the difference in density is considered. The pump efficiency, cavitation constant and NPSH requirements are also the same for slush hydrogen and triple-point liquid. After 34 minutes running time with slush hydrogen out of a total running time of 79 minutes, the pump components showed no wear over that expected from operation in liquid.

11281. Davis H. A., Jr., Hastings, J. R., Waxman, M., **An improved tool for refinishing the conical ends of high pressure tubing,** *Rev. Sci. Instr.* **40,** No. 9, 1238 (Sept. 1969).

Key words: Coning tool; high-pressure tubing; pressure seal.

A simple tool has been developed for refinishing the conical ends of high-pressure tubing in order to obtain a satisfactory seal in a coned-and-threaded connection. The tool uses the threaded portion of the tubing as the reference for alignment and can be used to refinish tubing that has a bend very close to the end of the tubing.

11282. Dean, J. W., Brennan, J. A., Mann, D. B., **Cryogenic flow research facility of the National Bureau of Standards,** (Proc. 1968 Cryogenic Engineering Conf., Case Western Reserve Univ., Cleveland, Ohio, Aug. 19-21, 1968), Chapter in *Advances in Cryogenic Engineering* **14,** Paper H-1, 299-305 (Plenum Press Inc., New York, N.Y., 1969).

Key words: Cryogenic fluid metering; cryogenics; flow loop, cryogenic.

The Cryogenics Division of the NBS Institute for Basic Standards is currently involved in an extensive cryogenic fluid metering program. The objectives of this program are to study cryogenic fluid measuring practices, to develop recommended practices for the most effective transfer of cryogenic fluids of interest in commerce, and to allow testing of new concepts in measurement.

This paper describes the experimental facility built to implement this program. The facility consists of a cryogenic flow loop with a dynamic gravimetric mass flow calibration capability. A pump delivers from .00126 to .0126 m^3/s (20 to 200 GPM) of nitrogen or argon at pressures up to 1.9 MN/m^2 (275 psia). 15 kw of refrigeration is available at 63 K (113 R) to remove the pump and heat leak energy and thus controls the temperature environment in the test section. An analysis of the system errors is presented to provide an understanding of the system operation.

11283. Dehl, R. E., Hoeve, C. A. J., **Broadline NMR study of H_2O and D_2O in collagen fibers,** *J. Chem. Phys.* **50,** No. 8, 3245-3251 (1969).

Key words: Anisotropic molecular motion; broadline NMR; D_2O in collagen; H_2O in collagen; proton exchange; quadrupole splitting.

The deuterium NMR spectra of D_2O absorbed in parallel collagen fibers have been recorded for samples containing four different percentages of D_2O. In all cases, the spectra consisted of a pair of lines, the separation of which is given by $K(3\cos^2\Theta-1)$, where K is small compared to the rigid-lattice value and decreases with increasing moisture content of the fibers, and Θ is the angle between the fiber axis and the magnetic field. The splitting is ascribed to quadrupole perturbation of the Zeeman levels of deuterium, caused by slightly anisotropic but rapid reorientation of D_2O molecules in the fiber lattice. Contrary to the interpretation by others, we have concluded from a comparison of the spectra of D_2O and H_2O in collagen (1) that the center line in the H_2O spectra is not due to water, and (2) that line broadening in the H_2O spectra, both at high temperatures and in the presence of added salts, is due to proton exchange between the water molecules. Molecular motion causes both H_2O and D_2O splittings to be reduced to approximately the same fraction of their respective rigid-lattice splittings.

11284. DeLancey, G. B., **Analysis of multicomponent diaphragm cell data,** *J. Phys. Chem.* **73,** No. 5, 1591-1593 (May 1969).

Key words: Coefficients; diaphragm cell; matrix logarithm; multicomponent diffusion.

An analytical technique is presented for the evaluation of multicomponent diffusion coefficients from standard diaphragm cell data. Unlike computational procedures now in use, (i) no experimental or mathematical restrictions are imposed, (ii) the number of chemical species in the experiment does not complicate the calculations, and (iii) the diffusion coefficients are explicitly related to experimentally measured quantities. The method employes the generalization of the scalar logarithm to matrix arguments.

11285. DeRis, J. N., **Spread of a laminar diffusion flame,** *Proc. Conf. Twelfth Symp. (International) on Combustion, Poitiers, France, July 17, 1968,* pp. 241-252 (Combustion Institute, Pittsburgh, Pa., 1969).

Key words: Combustion; conduction; diffusion flames; flame spread; heat transfer; integral equations; mass transfer; radiation; reaction kinetics; thermal properties.

This work considers the problem of a gas-phase laminar diffusion flame spreading against the wind over a solid or liquid fuel bed. Both a thin sheet and a semi-infinite fuel bed are considered. The burning process is described as follows. The hot flame heats the unburnt fuel bed, which subsequently vaporizes. The resulting fuel vapor reacts with the oxygen supplied by the induced air; thus producing the heat which maintains the flame spreading process.

A simplified model is formulated and subjected to mathematical analysis. This model treats the combustion as a diffusion flame for which the reaction kinetics can be ignored. The model includes the effects of gas-phase chemical combustion, gas-phase conductive heat transfer, radiation, mass transfer, fuel vaporization, and fuel bed thermal properties.

The calculated flame spread formulas are consistent with available experimental data. These results reveal much of the physics involved in a spreading flame. For instance, the reaction chemistry affects the flame speed only through the adiabatic stoichiometric flame temperature. While most of the fuel bed thermal properties are very important to the flame spread, the parallel fuel bed conductivity does not significantly affect the flame speed.

11286. Deslattes, R. D., Paretzkin, B., **A small set of reference crystals for double-crystal topography,** *J. Appl. Cryst.* **1,** Part 3, 176-178 (Sept. 1968).

Key words: Crystal perfection; silicon; topography.

A set of six reference crystals of silicon makes possible double crystal topography in the grating space range of 1-2 Å with Cu $K\alpha_1$ radiation.

11287. deWit, R., **Differential geometry of the nonlinear continuum theory of dislocation,** (Proc. IUTAM Conf. Stuttgart, Germany, Aug. 28-Sept. 2, 1967), Chapter in *Mechanics of Generalized Continua,* pp. 251-261 (Springer-Verlag, Berlin, Germany, 1968).

Key words: Affine connection; continuum; defect; deformation; dislocation; nonlinear; non-Riemannian geometry; torsion.

The differential geometric aspects of the limited nonlinear continuum theory of crystal dislocations are developed in terms of a non-Riemannian geometry with vanishing Riemann-Christoffel curvature. The emphasis is on a general notation and a covariant formulation of the theory. Comparisons are made with the works of Kröner and Eringen. The drawback of nondistant parallelism in passing to the general theory with nonvanishing curvature are discussed.

11288. Dibeler, V. H., Walker, J. A., **Mass spectrometric study of photoionization. XIV. Nitrogen trifluoride and trifluoramine oxide,** *Inorg. Chem.* **8,** 1728-1733 (1969).

Key words: Bond dissociation energies; heats of formation; ionization energies; mass spectra; NF_3; ONF_3; vacuum ultraviolet.

Photoionization yield curves for the NF_3^+, NF_2^+, and NF^+ ions of nitrogen trifluoride and the ONF_3^+, ONF_2^+, and NO^+ ions of trifluoramine oxide were obtained from threshold to 600 Å. Ionization energies were used to calculate heats of formation of ions, ionization energies of radicals, and bond dissociation energies. The high precision of the photoionization measurements were not fully utilized because of uncertainties in, or lack of, supporting thermal and spectral data. The following bond dissociation energies (in eV) were derived: $D(NF_2\text{-}F) = 2.43$, $D(NF\text{-}F) = 3.6$, and $D(NF) = 2.3$. The heat of formation, $\Delta Hf_0^\circ(ONF_3) = -2.87$ eV (-66 kcal mol^{-1}) was derived from ionization threshold data and used to estimate $D(O\text{-}NF_3) = 4.1$ eV, $D(ONF_2\text{-}F) = 1.9$ eV, and related thermodynamic properties.

11289. Dickens, B., Brown, W. E., **The crystal structures of $CaNa_2(CO_3)_2 \cdot 5H_2O$, synthetic gaylussite and $CaNa_2(CO_3)_2 \cdot 2H_2O$, synthetic pirrsonite,** *Inorg. Chem.* **8,** No. 10, 2093-2103 (Oct. 1969).

Key words: Carbonates; crystal structure; gaylussite; hydrated carbonates; hydrates; pirrsonite.

The crystal structure of gaylussite has been determined from single-crystal x-ray diffraction data. The unit cell is $a = 14.361 \pm .004$, $b = 7.781 \pm .002$, $c = 11.209 \pm .004$A, $\beta = 127.84 \pm .03°$, and the space group is C2/c. $R_w = (\Sigma(w\|F_o|-|F_c\|)^2)/\Sigma(w|F_o|)^2 = 0.043$. The hydrogen atoms have been located. Two CO_3 anions are coordinated to a Ca ion and form a dihedral angle of 134.3°. Each CO_3 group is coordinated to four Na ions and four water molecules, but to only one Ca ion. Each Na is coordinated to four CO_3 groups and two water molecules. Two water molecules form hydrogen bonds to neighboring CO_3, anions. The remaining water forms hydrogen bonds with the oxygens of two other water molecules.

The crystal structure of pirrsonite has also been determined from single-crystal x-ray diffraction data. The unit cell is $a = 11.340 \pm .004$, $b = 20.096 \pm .005$, $c = 6.034 \pm .002$A and the space group is Fdd2. $R_w = 0.029$. The hydrogen atoms have been located. As in gaylussite, two CO_3 anions are coordinated to a Ca ion but with a dihedral angle of 95.5°. In contrast to gaylussite, the CO_3 anions are also coordinated to a second Ca ion, as well as to four Na ions and two water molecules. Each Na ion is coordinated to four CO_3 anions and loosely to two water molecules. The water molecules complete the coordination of Ca ions and form hydrogen bonds with neighboring CO_3 anions.

11290. Dickson, R. W., Wachtman, J. B., Jr., Copley, S. M., **Elastic constants of single crystal Ni_3Al from 10 to 850 °C,** *J. Appl. Phys.* **40,** No. 5, 2276-2279 (Apr. 1969).

Key words: Aluminum; elastic constants; elastic moduli; nickel; single crystals; superalloy.

The elastic constants of single-crystal Ni_3Al were determined 10 to 850 °C by a resonance technique. The values of the compliance and their standard errors at 25 °C are $s_{11} = 0.927 \pm 0.015$, $s_{44} = 0.825 \pm 0.027$ and $s_{12} = -0.319 \pm 0.050$ in units of 10^{-11} m^2/N.

11291. DiMarzio, E. A., Guttman, C. M., **Separation by flow,** *J. Polymer Sci. Polymer Letters* **7,** 267-272 (1969).

Key words: Chromatography; gel permeation chromatography; polymer fractionation.

It is proposed that the separation in Gel Permeation Chromatography is due in part to the fact that polymer molecules of different volumes entertaining Brownian motion flow down capillary tubes with different mean velocities. The velocity of the polymer, v_p, for each position in the tube is found to be a linear function of the fluid's velocity at the polymer's center of mass. The average velocity of the polymer is then the average of v_p over those positions in the tube available to the polymer's center of mass. If one assumes a model in which a column is viewed as a bundle of capillary tubes then agreement with experiment is obtained. It is suggested fine capillary tubes or a bed of impermeable beads could be used to fractionate polymers.

11292. Dodd, J. N., Enemark, E., Gallagher, A., **Quenching of cesium resonance radiation by helium,** *J. Chem. Phys.* **50,** No. 11, 4838-4842 (June 1, 1969).

Key words: Cesium quenching; lifetimes.

Using the phase-shift technique to measure excited state lifetimes, upper limits of 1.5×10^{-14} cm^3/sec and 3×10^{-14} cm^3/sec have been established for the $Cs(6\,^2P_{1/2\ or\ 3/2}) + He \rightarrow Cs(6\,^2S_{1/2}) + He$ quenching rate constants at 350 and 820 K. (In "cross section" units these are equivalent to 10^{-19} cm^2 upper limits.) The natural lifetimes were measured to be $30.8 \pm 1.5 \times 10^{-9}$ sec and $35.2 \pm 1.5 \times 10^{-9}$ sec for the Cs $6\,^2P_{3/2}$ and $6\,^2P_{1/2}$ states.

11293. Domen, S. R., **Heat loss compensated calorimeter,** *Nature* **222,** No. 5198, 1061 (June 14, 1969).

Key words: Absorbed dose; calorimeter; heat loss compensation; heat flow theorem.

A new calorimetric design and measuring technique are proposed for reducing uncertainties caused by temperature gradients. A theoretical analysis revealed a mathematical theorem concerning heat transfer among the calorimetric elements.

11294. Donovan, R. J., Husain, D., Bass, A. M., Braun, W., Davis, D. D., **Kinetic spectroscopic studies of $Cl(3p^5\,^2P_{3/2,\,1/2})$ in the vacuum ultraviolet,** *J. Chem. Phys.* **50,** No. 9, 4115-4116 (May 1, 1969).

Key words: Atoms; chlorine; deactivation; kinetic; relaxation; vacuum ultraviolet.

Collisionally induced spin orbit relaxation of $CL(3^2P_{1/2})$ to $Cl(3^2P_{3/2})$ by various species M at room temperature have been measured and the results are summarized.

11295. Drechsel, D., Maximon, L. C., Warner, R. E., **Noncoplanar p-p bremsstrahlung calculations at 48 and 30 MeV,** *Phys. Rev.* **181,** No. 4, 1720-1722 (May 20, 1969).

Key words: Differential cross section; noncoplanar proton bremsstrahlung; off-the-energy-shell behavior; potential model calculation; proton-proton bremsstrahlung.

Cross sections for coplanar and noncoplanar proton-proton bremsstrahlung were calculated at 48 and 30 MeV, using the Hamada-Johnston potential. The coplanar results agree with those of Signell and Marker. The University of Manitoba p-p bremsstrahlung data were reanalyzed and new coplanar cross sections were extracted.

11296. Duerst, R. W., Kokoszka, G. F., **Hyperfine fields in dimeric metal ion complexes,** *J. Chem. Phys.* **51,** No. 4, 1673-1674 (Aug. 15, 1969).

Key words: Antisymmetrical exchange; copper(II)-nickel(II) pairs; dimeric complexes; e.p.r.; exchange-coupled metal ions; hyperfine fields; super-transferred hyperfine fields.

The electron paramagnetic resonance of dichlorobis(pyridine-N-oxide)copper(II) doped with metal ions in their plus two oxidation state has been observed at 77 K. The host lattice consists of complexes containing pairs of exchange-coupled copper(II) ions. The dopant ions enter the lattice substitutionally.

The A values observed in a plane perpendicular to the crystallographic c axis for Cu(II)-Ni(II) pairs, for Cu(II)-Pd(II) pairs (in which the Pd(II) ion's ground state is diamagnetic), and for Cu(II)-M(II) pairs (M may be Zn, Cd, or Pb) were 0.0102 cm^{-1}, 0.0128 cm^{-1}, and 0.0118 cm^{-1} respectively.

An elementary model accounts for the variations in the A values depending on the dopant metal ion. For Cu(II)-Ni(II) pairs, a small angular deviation of the principal z axis of the g tensor was also observed. An explanation of this effect is suggested in terms of the Dzyaloshinsky-Moriya antisymmetrical exchange term $[d \cdot (S_1 \times S_2)]$.

11297. Durst, R. A., **Determination of fluoride by analate additions potentiometry,** *Mikrochim. Acta,* pp. 611-614 (1969).

Key words: Analate additions potentiometry; fluoride; fluoride ion selective electrode; potentiometry.

A novel direct potentiometric technique called analate additions potentiometry has been applied to the determination of fluoride using a fluoride ion selective indicator electrode. As expected, the analytical results are comparable to those obtained by the standard additions technique. An error of less than 1 part in 1000 and a precision of about 0.5 percent was achieved. The technique should be most useful in the determination of small sample volumes which cannot be done by the standard additions method without prior dilution.

11298. Edmonds, D. K., Hork, J., **Cavitation in liquid cryogens,** (Proc. 1968 Cryogenic Engineering Conf., Case Western

Reserve Univ., Cleveland, Ohio, Aug. 19-21, 1968), Chapter in *Advances in Cryogenic Engineering* **14,** Paper G-4, 274-282 (Plenum Press Inc., New York, N.Y., 1969).

Key words: Cavitation; cavitation inception; cryogenic; cryogenic cavitation; developed cavitation; thermodynamic cavitation.

Cavitation characteristics of liquid hydrogen and liquid nitrogen flowing in a transparent plastic venturi have been determined and conventional cavitation inception parameter curves are given. Representative thermodynamic data, consisting of pressure and temperature measurements within fully-developed cavities, are also given; measured temperatures and pressures within the cavities were generally not in thermodynamic equilibrium. Existing theory was used to obtain equations which correlate the experimental data for developed cavities in liquid hydrogen or liquid nitrogen. The theory is extended to include the effect of cavity thickness and the experimental data are used to evaluate the results. Some recommendations for future work are given.

11299. Ehrlich, M., **Proposed National Bureau of Standards Program for the calibration of instruments used in high-energy electron and x-ray beams,** (Proc. Conf. High-Energy Radiation Therapy Dosimetry, New York, N.Y., June 1967), *Annal. N.Y. Acad. Sci.* **161,** No. 1, 139-145 (July 3, 1969).

Key words: Absorbed dose; calibration; electrons; ferrous-sulfate system; graphite calorimeter; interim program; photons; transfer standard; uniformity checks; ~1 to 50 MeV

The NBS Radiation Physics Division plans to develop services for calibrating suitable measuring instruments in terms of absorbed dose in low-atomic number materials, for use with electrons and photons in the energy range from approximately 1 to 50 MeV. As the standard instrument, NBS plans to use a graphite calorimeter, surrounded by a graphite block. For use in routine calibrations, a stable transfer instrument will be developed which requires less exacting measurements than the calorimeter.

Since the absorbed-dose calibration services based on calorimetry will not be immediately available, an interim program has been initiated for uniformity checks of high-energy electron-beam calibrations. Starting in July 1967, NBS will prepare and mail ferrous-sulfate solutions in sealed radiation-resistant spectrophotometer cells. A minimum of four cells will be supplied to each participant, two of them to be used as controls, and the other two to be exposed by the participant in a polystyrene phantom. Upon their return, NBS will evaluate the dose received by the ferrous-sulfate solutions, using the G-value recommended by the American Association of Physicists in Medicine.

11300. Evenson, K. M., **Microwave magnetic-dipole transitions between excited electronic states of CN,** *Phys. Rev.* **178,** No. 1, 1-4 (Feb. 5, 1969).

Key words: CN; double resonance; excited state; magnetic dipole transitions; microwave spectroscopy.

Eleven microwave transitions in the frequency range from 10.5 to 11.5 GHz have been observed between excited electronic states of CN. These correspond to 11 of 13 allowed magnetic dipole transitions, $\Delta F = 0, \pm 1$, in the $K' = 4$ perturbation complex between the three hyperfine levels of the perturbed component of the Λ doublet of the $A^2\Pi^+_{3/2}(v = 10)$ level and the three hyperfine levels in each of the perturbed and the unperturbed components of the spin doublet of the $B^2\Sigma^+$ $(v = 0)$ level. These transitions and the previously measured 13 electric dipole transitions determine all twelve hyperfine energy levels of this perturbation complex. The experiment is the first microwave measurement of magnetic dipole transitions between excited electronic states of a molecule. CN was produced predominately in the metastable $A^2\Pi$ state by a chemical reaction when methylene chloride was added to a nitrogen afterglow. Resonant microwave pumping from the Π state increased the population of the three hyperfine levels of each Σ state. The population change was detected by measuring an increase in the intensity of the $B^2\Sigma^+ \rightarrow X^2\Sigma^+$ (0,0) violet band of CN near 3875 Å.

11301. Fatiadi, A. J., **Acylation of tetrahydroxy-*p*-benzoquinone,** *J. Chem. Eng. Data* **13,** No. 4, 591-593 (Oct. 1969).

Key words: Acetates; benzenehexol; disproportionation; esters; rhodizonic acid; tetrahydroxyquinone.

Procedures are described for preparation of previously unreported di- and tetraacetates of tetrahydroxyquinone. Chemical proof is presented for disproportionation of tetrahydroxyquinone into benzenehexol (hexahydroxybenzene) and rhodizonic acid in a slightly basic solution. By use of this reaction, a series of acyl derivatives of benzenehexol has been prepared; certain esters of tetrahydroxyquinone also disproportionate in a slightly basic medium.

11302. Fatiadi, A. J., **Novel iodination of the α-methylene group in 1,3-diphenylpropane-1,3-dione and related β-diketones with periodic acid,** *Chem. Commun.*, p. 11 (1970).

Key words: Acyclic; iodic acid; iodo derivatives; periodic acid; β-diketones.

On treatment with iodic acid, 1,3-diphenyl-1,3-propanedione is converted into the 2-iodo derivative in about 50 percent yield. When periodic acid is used the diketone can be converted either into the 2-iodo or the 2,2-diiodo derivative. Formation of 2-iodo derivatives has been observed for other acyclic β-diketones.

11303. Fenstermaker, C. A., McCrackin, F. L., **Errors arising from surface roughness in ellipsometric measurement of the refractive index of a surface,** *Surface Sci.* **16,** 85-96 (1969).

Key words: Ellipsometry; index of refraction; light reflection; optical properties; rough surfaces.

The roughness of a surface is generally neglected when the refractive index of a material is calculated from ellipsometer measurements. Errors produced by neglecting the roughness of the surface are evaluated for three models of the topography of the surface (square ridges, triangular ridges, and pyramids). A range of roughness from 0 to 500 Å and six substrate materials (glass, silicon, chrome, mercury, gold, and silver) are considered. Large errors in determination of indices, even for small values of roughness (50 Å), were found.

11304. Flynn, D. R., O'Hagan, M. E., **Measurements of the thermal conductivity and electrical resistivity of platinum from 100 to 900 °C,** *Engelhard Indust. Tech. Bull.* **8,** No. 4, 117-147 (Mar. 1968).

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 distribution 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.

11305. Flynn, D. R., Watson, T. W., **Measurement of the thermal conductivity of soils at high temperature,** *Atomic Energy Report SC-CR-69-3059* (Apr. 1969).

Key words; Conductance; conductivity; heat transfer; nuclear safety; soils; temperature; thermal conductance; thermal conductivity.

An apparatus is described which has been designed and built to enable measurement of the thermal conductance of soils at hot face temperatures approaching 1700 °C. The method utilizes radial heat flow through a hollow cylinder of soil contained between a central ceramic core and an outer water-cooled metal shell. Thermal conductivity values are reported for nine natural or artificial soils representative of subsoils found on most of the earth's surface. For each of these soils, measurements have been completed on two different specimens under particular but reproducible conditions of preparation.

11306. Flynn, T. M., Birmingham, B. W., **Cryogenics and national goals,** (Proc. 1968 Cryogenic Engineering Conf., Case Western Reserve Univ., Cleveland, Ohio, Aug. 19-21, 1968), Chapter in *Advances in Cryogenic Engineering* **14**, Paper A-1, 1-12 (Plenum Press Inc., New York, N.Y., 1969).

Key words: Agriculture; compressed gases; conservation; cryogenics; education; health; national goals; space; transportation.

The object is to discuss a segment of the compressed gas industry, namely the cryogenic industry, and its relation to selected national programs, such as space, health, agriculture, transportation, conservation, and education.

11307. Frederick, N. V., **A low loss sliding short of limited travel for precision coaxial transmission lines,** *Proc. IEEE* **56**, No. 12, p. 2188 (Dec. 1968).

Key words: Coaxial cavity tuning; coaxial short; precision transmission line; reflection coefficient; sliding short.

A precisely adjustable sliding short with high reflection coefficient is described. The reflection coefficient is approximately .996 at 4 GHz. Instructions are given for fabrication. The device is especially useful for measuring electrical lengths and for tuning of coaxial cavities and for coaxial line bridge work.

11308. Frederick, N. V., **A new high-frequency current standard,** *IEEE Trans. Instr. Meas.* **IM-17**, No. 4, 285-290 (Dec. 1968).

Key words: Ammeter; electrodynamometer; high frequency current; short-circuited ring; torsion balance.

A short-circuited-ring electrodynamic ammeter is described. The short-circuited-ring is supported by a fine quartz fiber and is suspended midway between the inner and outer conductors of a coaxial transmission line. The current on the line is measured by measuring the torque exerted against the ring by the current on the coaxial line. A new technique is given for determining the relationship between the torque on the ring and the current on the transmission line and is compared with the technique which has been used in the past. The new method is an application of the resonator action theorem used by A. L. Cullen for calibrating a torque operated microwave wattmeter. The major weakness in the previous evaluations of the torque current relation is discussed. The ammeter is useful for measuring current from one to one hundred amperes over the frequency range 1 MHz to 1 GHz with an uncertainty of the order of 0.5 percent.

11309. Frederikse, H. P. R., Hosler, W. R., Casella, R. C., **Piezoresistive effects in semiconducting strontium titanate,** *Proc. Ninth Intern. Conf. Physics of Semiconductors, Moscow, USSR, July 23-29, 1968*, pp. 1175-1180 (NAUKA, Leningrad, USSR, 1968).

Key words: Piezoresistive effects; semiconductors; strontium titanate.

Piezoresistive effects in doped $SrTiO_3$ measured at 300, 77, and 4 K are interpreted in terms of many-valleyed energy band model [spheroids along $\langle 100 \rangle$ directions]. Low temperature saturation is explained by assuming domain flipping under stress.

11310. Furukawa, G. T., **Automation problems in thermometry and calorimetry,** (Proc. 2nd & 3rd Japanese Calorimetry Conf., Osaka, Japan, Nov. 27-28, 1967), Chapter 1 in *Calorimetry, Thermometry, and Differential Thermal Analysis*, Y. Otsubo, H. Kanbe, and S. Seki, eds., **2**, 1-35 (Kagaku Gijitsu-Sha, Tokyo, Japan, 1969).

Key words: Automatic calorimetry; calorimetry; heat capacity; Mueller bridge; thermometry.

For high-precision low-temperature calorimetry, the techniques used in measurement periods of temperature and of power are discussed separately. The application of electronic preset counters to automatic control of the calorimetric process is proposed. The thermometer resistances are measured by means of an automated Mueller bridge and the measurements are analyzed on a high-speed digital computer to obtain temperature-time observations. The electrical power introduced is automatically determined using a commercially available intergrating digital voltmeter (IDVM) to measure a small fraction of the total calorimeter heater voltage biased by a stable reference voltage. A modification of the IDVM to integrate over the heating interval to obtain the total electrical energy input is described.

11311. Gadzuk, J. W., **Band-structure effects in the field-induced tunneling of electrons from metals,** *Phys. Rev.* **182**, No. 2, 416-426 (June 10, 1969).

Key words: Band structure; density of states; field emission; surface physics; tunneling.

The theory of electron tunneling from metals into vacuum is investigated. Certain ambiguous conclusions reached in previous theoretical treatments are reconsidered. It is found that band structure information is contained in the total energy distribution of field emitted electrons.

The problem of electron tunneling from narrow energy bands with a high density of states, well described in the tight binding approximation, is treated. Expressions for the tunneling matrix element of electrons in tight binding d bands tunneling to free electron states outside the metal are obtained within the field ionization approximation of Oppenheimer.

Calculations are then given for the energy distribution of field emitted electrons coming from a model of a real metal in which the band structure is a superposition of a free s like band and a tight binding d band. This is a reasonable qualitative model for the band structure of a noble metal. The relationship between energy distribution and the band structure is established.

11312. Gadzuk, J. W., **Many-body tunneling-theory approach to field emission of electrons from solids,** *Surface Sci.* **15,** 446-482 (1969).

Key words: Electrons in solids; electron tunneling; field emission; many-body theory; surface physics.

The equation of motion and thermodynamic Green's function method for describing tunneling processes in normal and Josephson junctions is here adapted to the problem of field emission of electrons from solids. The formal developments lead to an equation for the emission current in terms of both the Fowler-Nordheim quantities and the spectral weight function of the single particle Green's function in the solid. The formal results are examined in detail for three specific examples.

In the case when the spectral function is that of a free, noninteracting electron gas, the formal results obtained here reduce to the usual Fowler-Nordheim result for the current and the energy distribution.

Expressions are then obtained for the current and energy distribution of field emitted electrons from superconductors. The consequences of these results are discussed.

The last example here is probably the most interesting from the experimental point of view. The emission current characteristics from an electron gas in which collisions between electrons and phonons, electrons, impurities, or imperfections occur are analyzed. The damping of the electron energy eigenstates, which is present in all real metals, results in new current characteristics for energies near the Fermi surface. The derived energy distributions are smeared about the Fermi energy. The degree of smearing is a function of the temperature dependent electron-phonon or electron-electron collision time. It is thus shown how to go backwards from the smeared energy distributions to obtain information pertinent to the electron-phonon interaction and the imaginary part of the bare electron self energy in the phonon field.

11313. Garvin, D., **Suggestion: the minireview,** *Phys. Today* **22,** No. 10, 13-15 (Oct. 1969).

Key words: Chemistry; evaluation of data; information retrieval; physics; publication; reference data; review.

It is suggested that the need for substantive reviews and evaluated data can be met, in part, by encouraging research scientists to write short evaluations based on topics that grow out of their own work. The preferred publication medium would be evaluation sections in the journals that normally cover the pertinent field.

11314. Gatterer, L. E., **Clock synchronization experiments at VHF utilizing the ATS-1 and ATS-3 transponders,** *Natl. Aeronaut. Space Admin. Report ATS Tech. Summary* (National Aeronautics and Space Administration, Greenbelt, Md., Feb. 16, 1968).

Key words: Atomic standards; ATS-1; clock synchronization; time dissemination; VHF propagation satellite timing.

Experiments are described which repeat demonstrations of the effectiveness of a technique for synchronizing widely separated clocks to better than 10 μsec, and which investigate extensions of this technique. Preliminary results are described. These experiments utilized the VHF transponder on ATS-1.

11315. Grenley, D. G., **Study of the effect of certain modified mortars on compressive and flexural strength of masonry,** (Proc. Intern. Conf. Masonry Structural Systems, University of Texas, Austin, Texas, Nov. 30-Dec. 2, 1967), Chapter in *Designing Engineering and Constructing with Masonry Products,* F. B. Johnson, ed., Paper 5, pp. 28-33 (Gulf Publ. Co., Houston, Texas, May 1969).

Key words: Compressive strength of clay masonry; flexural strength of clay masonry; high strength mortars; improved mortars; masonry; modified mortars.

The use of high strength mortars materially improves the flexural and compressive strength of small masonry assemblages. This is found to be true with a variety of brick although there is indication that low quality brick will not experience a great degree of improvement in their structure strength. Brick and mortar strength are shown to be important factors in determining structure strength, however these variables alone will not permit a quantitative prediction of structure performance.

11316. Grenley, D. G., Cattaneo, L. E., Pfrang, E. O., **Effect of edge load on flexural strength of clay masonry systems utilizing improved mortars,** (Proc. Intern. Conf. Masonry Structural Systems, University of Texas, Austin, Texas, Nov. 30-Dec. 2, 1967), Chapter in *Designing Engineering and Constructing with Masonry Products,* F. B. Johnson, ed., Paper 17, pp. 119-128 (Gulf Publ. Co., Houston, Texas, May 1969).

Key words: Compressive interaction in walls; compressive strength of walls; flexural interaction in walls; flexural strength of walls; high bond strength mortars; improved mortars; masonry walls.

This paper proposes a theoretical interaction diagram for the effect of edge load and flexural load on the ultimate strength of masonry wall panels. Four experimental systems show good agreement with the theory and suggest a new approach to the rational design of masonry systems. The paper also indicates that substantial improvement in the strengths of masonry systems can be realized by improving the mortars used in their construction.

11317. Gugeler, A. L., Ballard, D. B., **The aluminum-porcelain enamel interface as observed by electron microscopy,** *Am. Ceramic Soc. Bull.* **48,** No. 9, 842-845 (Sept. 1969).

Key words: Adherence; aluminum; electron microscope; interface; porcelain enamel; spall resistance.

The electron microscope was used in a study of the adherence of porcelain enamel to aluminum. Various combinations of aluminum alloys and metal pretreatments were studied. Shadowed plastic surface replicas of the porcelain enamel-aluminum interface were taken from polished and etched cross sections. Those combinations which had poor adherence, as indicated by low resistance to spalling, had a layered structure at the interface. This thin layer was not observed in those specimens which were considered to have good adherence. The susceptibility of the layered structure at the interface to corrosive attack appears to have a direct relationship to spall resistance.

11318. Halldane, J. F., **Visual responses of travelers in urban environments,** (Proc. Symp. Man-Machine Systems, Cambridge, England, Sept. 8-12, 1969), Chapter in *Transport Systems Vehicle Control* **2,** Paper No. 8, 17 pages (1969).

Key words: Environmental design; human factors; interdisciplinary study; relative motion; transportation; urban design; visual responses.

The contribution of a psychophysical discipline is discussed in relation to the visual problems of urban design and vehicle control. In town planning, the visual fields of urban observers have mainly been considered from the aspect of architectural form and the designer has had difficulty in communicating those problems in the context of other planning disciplines. While we have developed sophisticated physical techniques of measuring visual stimuli in transportation engineering, we do lack knowledge both in the implications of the response criteria adopted for sensory investigations and in the methods of analysing experimental data.

The paper contributes to planning and transportation by introducing a psychophysical synthesis as an interdisciplinary means of posing and solving the visual problems of people moving within urban environments. A planning philosophy is developed where the response problems are derived from the behavioral goals inherent within the planning program. A psychophysical synthesis is then applied to establish a valid range of physical stimuli. Those stimuli in turn suggest possible distributions of the environmental systems to achieve the design. Whether the responses are to be minimised, maximised, optimised or negated become the prerogative of the designer according to the original goals.

11319. Hanley, H. J. M., Childs, G. E., **Dilute gas viscosities at low temperatures,** *J. Chem. Phys.* **50,** No. 10, 4600-4601 (May 15, 1969).

Key words: Argon; correlation; dilute gas viscosity; kinetic theory; potential functions.

We recently reported that the tabulated and generally accepted viscosity coefficients for simple gases could be systematically in error at high temperatures (>300 K). We have extended our work to cover viscosity data at low temperatures. We again find factors indicating possible errors in experimental data (although not as great as before) which reinforce our opinion that the whole subject of dilute gas viscosities needs careful reexamination.

11320. Hanley, H. J. M., Klein, M., **Selection of the intermolecular potential function, III. From the isotopic thermal diffusion factor,** *J. Chem. Phys.* **50,** No. 11, 4765-4770 (June 1, 1969).

Key words: Fitting of experimental data; isotopic thermal diffusion coefficient; potential function families; sensitivity of coefficient.

A method developed previously to evaluate quantitatively the relationship between intermolecular potential functions and macroscopic properties is extended to the isotopic thermal diffusion factor. As before, the relationship between function families has been clarified. In particular, an insensitive temperature range, here about $2 \leqslant T^*_{12,6} \leqslant 4$, was found in which the data do not permit the selection of a function. The function families studied were the m-6, Kihara, and exp-6. A quantitative evaluation of the sensitivity of the thermal diffusion coefficient to the potential function is presented.

11321. Hardy, S. C., Coriell, S. R., **Morphological stability of cylindrical ice crystals,** *J. Crystal Growth* **5,** 329-337 (1969).

Key words: Crystal growth; cylinder; ice; morphological stability; surface tension; water.

Small, single crystal ice cylinders have been grown into undercooled water. The initially smooth crystals develop sinusoidal perturbations about the circumference and parallel to the axis. The growth rates and wavelengths of these perturbations are in quantitative agreement with the predictions of a Mullins-Sekerka stability analysis. The growth rates of the perturbations along the axis yield a value of .022 J/m^2 (22 erg/cm^2) for the ice-water surface tension.

11322. Hendricks, R. C., Simoneau, R., Smith, R. V., **Heat transfer with a near-critical fluid,** *Natl. Aeronaut. Space Admin. Report TNX 52612* (National Aeronautics and Space Administration, Greenbelt, Maryland, June 16, 1969).

Key words: Choking; critical; fluid flow; heat transfer; oscillations.

The three authors have reviewed the field and added some new material. The intent of the paper is to bring the literature together, to provide information for designers, and to suggest needed research.

11323. Herbert, R. L., Tryon, M., Wilson, W. K., **Differential thermal analysis of some papers and carbohydrate materials,** *Tappi* **52,** No. 6, 1183-1188 (June 1969).

Key words: Carbohydrate materials; differential thermal analysis; papers.

A study of the thermal degradation of various types of papers by differential thermal analysis (DTA) showed two distinct endothermic peaks, one at 135-155 °C, indicating loss of sorbed moisture, and the other at 310-365 °C, indicating massive decomposition. When the papers are ranked in order of decreasing temperature of the decomposition endotherm, and in decreasing pH values, a high correlation is indicated. Data on the DTA of several carbohydrate compounds related to cellulose also are presented.

11324. Herron, J. T., Huie, R. E., **Rates of reaction of atomic oxygen. II. Some C_2 to C_8 alkanes,** *J. Phys. Chem.* **73,** No. 10, **chloroalkanes and bromoalkanes,** *J. Phys. Chem.* **75,** No. 5, 1326-1335 (May 1969).

Key words: Atomic oxygen; bromoalkane; chemical kinetics; chloroalkane; mass spectrometry; organic compounds; rate constant.

A method for measuring rate constants for the reactions of atomic oxygen (^3P) with organic compounds is described. Rate constants and Arrhenius parameters are reported for the reactions of atomic oxygen with twelve chloroalkanes and bromoalkanes from 336 to 622 K.

11325. Herron, J. T., Huie, R. E., **Rates of reaction of atomic oxygen, II. Some C_2 to C_8 alkanes,** *J. Phys. Chem.* **73,** No. 10, 3327-3337 (Oct. 1969).

Key words: Alkane; atomic oxygen; chemical kinetics; mass spectrometry; organic compounds; rate constant.

Rate constants have been measured for the reactions of atomic oxygen (O^3P) with eight straight and branched chain alkanes from 250 to 600 K, and for six other branched chain alkanes at 307 K. The reactions are interpreted on the basis of a hydrogen atom abstraction mechanism, and Arrhenius parameters are derived for abstraction of primary, secondary, and tertiary hydrogen atoms. The activation energies are found to be in the order primary > secondary > tertiary. For abstraction at secondary C – H bonds, the activation energy is observed to decrease with increasing molecular complexity of the alkane.

A method of estimating rate constants is given.

11326. Hiza, M. J., Duncan, A. G., **Comments on "Intermolecular forces: Thermal diffusion and diffusion in He-Kr and H_2-Kr,"** *Phys. Fluids* **12,** No. 7, 1531-1532 (July 1969).

Key words: Beam scattering data; characteristic energy parameters; deviations from geometric mean diffusion properties; equilibrium properties.

Comments on a paper, "Intermolecular Forces: Thermal Diffusion and Diffusion in He-Kr and H_2-Kr" by Annis, Humphreys, and Mason published in "The Physics of Fluids," October 1968.

11327. Hiza, M. J., Duncan, A. G., **Equilibrium gas-phase compositions of ethane and ethylene in binary mixtures with helium and neon below 150 K and a correlation for deviations from the geometric mean combining rule,** (Proc. 1968 Cryogenic Engineering Conf., Case Western Reserve Univ., Cleveland, Ohio, Aug. 19-21, 1968), Chapter in *Advances in Cryogenic Engineering* **14,** Paper B-1, 30-40 (Plenum Press Inc., New York, N.Y., 1969).

Key words: Correlation for deviations from geometric mean combining rule; equilibrium gas-phase compositions;

ethane; ethylene; helium; helium-ethane system; helium-ethylene system; liquid-vapor equilibrium; low-temperature phase equilibrium; neon.

Equilibrium gas-phase compositions in the systems helium-ethane and helium-ethylene were measured along six and seven isotherms, respectively, between 90 and 150 K up to 130 atm pressure. Corresponding measurements were made in the systems neon-ethane and neon-ethylene along two isotherms each, but only up to 50 atm pressure. A single-pass flow apparatus was used with continuous anlaysis for ethane or ethylene by means of a hydrogen flame-ionization detector. These data complete a set of nine binary systems containing hydrogen, helium, and neon with light hydrocarbons which are the basis of a correlation relating the deviations from the geometric mean combining rule to the ionization potentials of the component species.

11328. Hoer, C. A., Smith, W. L., **A 1-MHz binary inductive voltage divider with ratios of 2ⁿ to 1 or 6n dB,** *IEEE Trans. Instr. Meas.* **IM-17,** No. 4, 278-284 (Dec. 1968).

Key words: Attenuator; binary divider; inductive voltage divider; ratio transformer; voltage comparator; voltage divider.

A voltage divider with ratios of 2^n:1 or 6n dB is obtained by cascading n binary dividers, each having a voltage ratio 2:1. A theoretical analysis results in an expression for the ratio error. Several techniques are given for reducing this error. A voltage comparator is described for eliminating errors due to external loading of the divider. An experimental cascaded binary divider with a total of 42 dB in seven 6 dB steps is described. The attenuation of the divider was measured with a precision waveguide below-cutoff attenuator at 1 MHz. The divider and attenuator values agree within the uncertainty of the attenuator and measuring system at 1 MHz.

11329. Hoffman, J. D., Lauritzen, J. I., Jr., Passaglia, E., Ross, G. S., Frolen, L. J., Weeks, J. J., **Kinetics of polymer crystallization from solution and the melt,** *Kolloid-Z. Polymere* **231,** Nos. 1-2, 564-592 (1969).

Key words: Bulk; chain fold; crystallization; fluctuation; growth; heat of melting; homogeneous nucleation; kinetics; lamella thickness; melt; melting point; nucleation; polymer; solution; surface free energy; theory; thermodynamics.

Kinetic nucleation theories of the growth of chain-folded polymer crystals from the melt and dilute solution are reviewed, and attention focussed on the recent treatment of Lauritzen and Passaglia (LP), which includes the effect of fluctuations in the fold period. The LP fold surface is rough, and contains terms resulting from the σ-type surface of the projecting folds, and the entropy of mixing. The relationship to earlier theories is indicated. The LP theory predicts that the "kinetic" value of the fold surface free energy, $\sigma_{e(k)}$ increases with increasing undercooling. An adjunct theory is given that approximately predicts the temperature dependence of the lateral surface free energy, σ, as $x=0.01$ in $\sigma=\sigma_1(1+x\cdot\Delta T)$. After review of the input data, expressions of the form $\sigma_{e(k)}=\sigma_{e(1)}[1+y\cdot\Delta T]$ and $\sigma=\sigma_1[1+x\cdot\Delta T]$ are employed to analyse homogeneous nucleation and growth rate data on polyethylene (bulk and dilute solution) to obtain fairly close estimates of y and σ_1. Melting point data give the approximate value of $\sigma_{e(1)}$. Predictions are then made for single crystals of the initial lamellar thickness l^*_g, the melting point T_m, and the heat of fusion defect, λ_H. Good agreement is obtained with $x=0.01$ deg^{-1}, $y=0.0135$ deg^{-1}, $\sigma_1=13.0$ erg cm^{-2} and $\sigma_{e(1)}=67.5$ erg cm^{-2}. The LP theory is capable of predicting the temperature dependence found for $\sigma_{e(k)}$. The nature of the fold surface in single crystals and bulk is discussed in some detail. The roughness of the fold surface associated with $\sigma_{e(k)}$ is calculated to have a rms deviation from the mean of 5.6 Å at the melting point, and about twice this figure at the homogeneous nucleation temperature. These estimates are consistent with the existence of a density defect. It is concluded that the LP form of the kinetic nucleation theory explains the growth rates observed for polyethylene, gives the lamellar thickness, and leads to the thermodynamic properties of the crystal produced by the growth mechanism.

11330. Hubbell, J. H., **Gamma-ray cross-section evaluation and compilation,** *Proc. Special Sessions on Gamma-Ray Production and Transport and on Civil Defense Shielding, Winter Meeting of the American Nuclear Society, Nov. 5-9, 1967, Chicago, Ill.,* A. E. Straker, ed., ANS-SD-7, AEC TID-4500 Series, pp. 71-77, 82-100 (Aug. 1969).

Key words: Compilations; energy absorption coefficients; gamma ray coefficients; photon attenuation coefficients; photon cross sections; x-ray attenuation coefficients.

A brief history of compilation activity in the field of photon attenuation coefficients is given. Available experimental attenuation coefficient data are reviewed for Z = 1 to 100 and photon energies 10 eV to 100 GeV with indications given of gaps and uncertainties. Mention is made of recent and in-progress compilations at NBS, LRL (Livermore) and elsewhere, and of the existence of an NSRDS (National Standard Reference Data System) "X-ray attenuation coefficient information center" at the NBS.

11331. Hudson, G. E., Allan, D. W., Barnes, J. A., Hall, R. G., Lavanceau, J. D., Winkler, G. M. R., **A coordinate frequency and time system,** *Proc. 23rd Frequency Control Symp., Atlantic City, N.J., May 6-8 1969,* p. 249 (1969).

Key words: Coordinate time; local atomic standards; metric time; national unified atomic standards; proper time; universal coordinated time.

A coordinate frequency and time system, suitable for extension to worldwide coverage, is described in relation to the form evolving in the United States. It consists of a network of component primary and associated stations, at fixed locations and altitudes, and a reference coordinating component at a reference location and altitude. A unified local atomic standard for the system serves as the coordinating component.

The system could be extended internationally, by regarding the national unified standards as components of an international one whose assigned frequency would equal f(Cs).

11332. Hudson, G. E., Barnes, J. A., **Clock error statistics as a renewal process,** *Proc. 22nd Frequency Control Annual Symp., Atlantic City, N.J., Apr. 22-24, 1968,* pp. 384-413 (1968).

Key words: Clock errors; dispersion of clock reading; flicker noise; random-walk noise; renewal equation; renewal processes; statistics of clock ensembles; white noise; zero crossings.

A model ensemble specifying the distribution of its clock readings about their average obeys an integral equation of renewal type. Renewal processes ordinarily describe when mechanical or electrical components need to be replaced. In this case, clocks in the ensemble may repeatedly read correctly and "renew" themselves. Solutions of the equation are discussed and are related to other error statistics.

11333. Hudson, R. P., **The CMN temperature scale,** *Proc. XI Conf. Low Temperature Physics, St. Andrews, Scotland, Aug. 21-28, 1968,* **I,** 501-504, Paper D1.8 (University of St. Andrews, Scotland, 1968).

Key words: Adiabatic demagnetization; cerous magnesium nitrate; low temperature scales.

A re-examination of adiabatic demagnetization results for cerous magnesium nitrate (CMN) shows them to agree with Van Vleck's theory of dipole-dipole interaction for the region above 0.01 K. To pursue the examination to lower temperatures, one requires fourth order and higher terms in the 1/T expansion, which are not yet available. They have therefore been obtained by least squares fitting and so provide a polynomial formula for the entropy which may be used to calculate the heat capacity. The latter is of interest in comparing magnetic temperature scales for CMN obtained by different methods.

11334. Huget, E. F., Brauer, G. M., Kumpula, J. W., Civjan, S., **A filled cold-curing acrylic resin as a splinting material,** *J. Am. Dent. Assoc.* **79,** 645-648 (Sept. 1969).

Key words: Acrylic splint; auto-polymerizing acrylics; biomaterial containing filled acrylic resin; low peak temperature polymers; stabilizing material for fractures and implants.

A polymeric material suitable for the rapid fabrication of splint type appliances has been developed. The dough-like product formed on mixing a powder and liquid can be readily adapted to the cervical third of the intact teeth. Auto-polymerization occurs in the mouth within 6 minutes at peak temperatures not exceeding 50 °C. The polymerized product exhibits sufficient strength, rigidity and dimensional stability to function as a splint.

This material may also find application for the fabrication of orthopedic splints and other medical uses.

11335. Hummer, D. G., **Noncoherent scattering—VI. Solutions of the transfer problem with a frequency-dependent source function,** *Mon. Not. R. Astr. Soc.* **145,** 95-120 (1969).

Key words: Doppler broadening; noncoherent scattering; radiation scattering; spectral line.

A generalized discrete-ordinate method is used to obtain accurate numerical solutions of the line transfer problem in what the scattering is described by a redistribution function. Extensive results are obtained and discussed for the cases of pure Doppler broadening and of Doppler and natural broadening combined. It is shown that, in the latter case, the intensity of radiation emerging from a semi-infinite isothermal atmosphere approaches that for coherent scattering in the line wings instead of approaching the value of the Planck function.

11336. Hust, J. G., Powell, R. L., **Thermal conductivity of aerospace alloys at cryogenic temperatures,** (Proc. 8th Conf. Thermal Conductivity, Purdue University, West Lafayette, Ind., Oct. 7-10, 1968), Chapter in *Thermal Conductivity*, C. Y. Ho and R. E. Taylor, eds., pp. 197-208 (Plenum Press Inc., New York, N.Y., 1969).

Key words: Aluminum alloy; electrical resistivity; Lorenz ratio; nickel alloy; thermal conductivity; thermopower; titanium alloy.

The apparatus described at the last Thermal Conductivity Conference has been used to determine the thermal conductivity, electrical resistivity, Lorenz ratio, and thermopower of several aerospace alloys between 4 and 300 K: titanium A-110 AT, Inconel 718*, Hastelloy X*, and aluminum 7039. These data are presented graphically. By utilizing detailed numerical and theoretical analyses, we have been able to separate the electronic and lattice contributions to the total thermal conductivity. Various scattering mechanisms have also been resolved for both types of conduction. The first three alloys are predominately lattice conductors at low temperatures, with total Lorenz numbers as high as $15 V^2/K^2$ near 20 K.

11337. Isbell, H. S., Fatiadi, A. J., **Phenylhydrazone-phenylazo tautomerism. Part III. Reactions of phenylformazans and certain bis(phenylhydrazones) with strong acids,** *Carbohydrate Res.* **11,** 303-311 (1969).

Key words: Cation; charge-resonance; diphenylformazan; heteropolar; protonation; structure; 1,3-bis(phenylhydrazone).

The behavior of diphenylformazans, 2-oxo-1,3-bis(phenylhydrazones), 1,2-bis(phenylazo)ethylene, and the phenylhydrazone of 4-oxo-1-phenyl-5-phenylazo-3-pyridazinecarboxaldehyde on protonation has been examined spectrophotometrically. These compounds form purple, blue, or green protonated cations. The nature of the spectral changes suggest that the highly colored cations have extended, heteropolar, charge-resonance structures. Phenylosazones and bis(phenylhydrazono) compounds that cannot form extended charge-resonance structures involving the phenyl groups and the adjoining nitrogen atoms do not usually give the blue color reaction. Structures are proposed for the cations derived from diphenylformazans, and certain 2-oxo-1,3-bis(phenylhydrazones).

11338. Isbell, H. S., Frush, H. L., Wade, C. W. R., Hunter, C. E., **Transformations of sugars in alkaline solutions,** *Carbohydrate Res.* **9,** 163-175 (1969).

Key words: Acyclic intermediates in mutarotation of sugars; aldoses, enolization of; alkaline rearrangement of sugars; enediols of sugars; enolization, measurement by tritium exchange; inososes, enolization of; ketoses, enolization of; mutarotation of sugars; rearrangement of sugars in alkali; sugars, enolization and rearrangement of; tritium exchange, measurement of enolization by; 2-deoxy sugars, enolization of.

A comparative study has been made of the rates of enolization of sugars in alkaline tritiated water, by measurement of their rates of tritium exchange. Based on the rate for D-glucose as unity, the rates of tritium exchange under a specific set of conditions range from 0.5 to 4.5 for aldohexoses, 0.5 to 10.7 for adloheptoses, 4.1 to 28 for aldopentoses, 2.6 to 25 for various ketoses, 0.3 to 0.8 for some 6-deoxy sugars, 90 to 155 for some 2-deoxy sugars, 2.0 to 240 for some disaccharides, and 1000 to 1500 for some inososes. To account for differences in the behavior of epimeric sugars in alkaline solution, it is suggested that the mutarotation reaction proceeds through pseudoacyclic intermediates that possess some characteristics of the respective ring forms. This new concept, applied to the interpretation of enolization reactions, leads to the possibility of formation of *cis-* and *trans-*enediols, the proportions of which may differ from sugar to sugar.

11339. Jackson, J. L., Lifson, S., Coriell, S. R., **Association times of counterions to polyelectrolytes in solution,** *J. Chem. Phys.* **50,** No. 11, 5045 (June 1, 1969).

Key words: Conductivity; counterion; diffusion; polyelectrolyte; transference; transit time.

The experiments of Wall on the transference of sodium ion in polyelectrolyte solutions indicated that the counterion was associated with the polyion for a relatively long time. A calculation of Lifson and Jackson indicated that electrostatic forces could not explain these long association times. Recently, Manning has calculated the counterion current in a polyelectrolyte solution in the presence of an applied field. In this comment, we discuss the transference experiments in light of the calculations of Lifson and Jackson and Manning.

11340. Jacox, M. E., Milligan, D. E., **Matrix-isolation study of the infrared and ultraviolet spectra of several first-series transition-metal dichlorides,** *J. Chem. Phys.* **51,** No. 9, 4143-4155 (Nov. 1, 1969).

Key words: Cl_2 reactions; $CoCl_2$; $CrCl_2$: emission spectrum; $FeCl_2$; infrared spectrum; matrix isolation; $MnCl_2$;

molecular orbitals; $NiCl_2$; transition-metal reactions; ultraviolet spectrum.

Individual molecules of $CrCl_2$, $MnCl_2$, $FeCl_2$, $CoCl_2$, and $NiCl_2$ have been isolated in an argon matrix at 14 K in sufficient concentration for infrared and ultraviolet spectroscopic study not only by using the conventional effusion cell as a source of the MCl_2 species, but also by trapping the products of the reaction of chlorine with the hot transition-metal surface. Studies of the infrared spectra of all of these species in the 250-4000-cm^{-1} spectral range are consistent with a linear structure. Ultraviolet absorptions in the 2000-5500 Å spectral range are in good agreement with the previously reported gas-phase absorptions. However, the absorption observed for matrix-isolated $NiCl_2$ between 4400 and 5000 Å must be attributed to three different electronic transitions, one of which exhibits extensive band structure. A molecular-orbital treatment involving participation of the 3d nickel electrons in the bonding of the molecule predicts the occurrence of several transitions in this energy range and provides a framework for understanding the appearance of extensive vibrational structure in several of the electronic transitions of $NiCl_2$.

11341. Jacox, M. E., Milligan, D. E., **Matrix-isolation study of the vacuum-ultraviolet photolysis of methyl fluoride. The infrared spectra of the free radicals CF, HCF, and H_2CF,** *J. Chem. Phys.* **50,** No. 8, 3252-3262 (Apr. 15, 1969).

Key words: Carbon atom reaction; CF; force constants; HCF; H_2CF; HF reaction; infrared spectrum; isotopic substitution; matrix isolation; methyl fluoride; thermodynamic properties; ultraviolet spectrum; vacuum-ultraviolet photolysis.

Upon vacuum-ultraviolet photolysis of methyl fluoride in an argon or a nitrogen matrix at 14 K, the free radicals CF, HCF, and H_2CF are stabilized in sufficient concentration for observation of their infrared absorption spectra. Studies utilizing carbon-13 and deuterium substitution confirm the identification of these species. Visible-ultraviolet absorption spectra of photolyzed Ar:CH_3F samples include bands which may be assigned to CH, to CF, and to HCF. The reaction of carbon atoms, produced by the photolysis of cyanogen azide isolated in an argon matrix, with HF trapped in the matrix has also been found to lead to the stabilization of sufficient HCF for infrared spectroscopic detection. Reaction of HCF with a second molecule of HF to form CH_2F_2 also occurs. The force constants and thermodynamic properties of HCF have been calculated, and a partial vibrational assignment is proposed for H_2CF. Although these experiments do not determine the primary photodecomposition processes important for methyl fluoride, there is evidence that both H atom and F atom detachment may occur under the conditions of these experiments.

11342. Jefferson, C. F., Baker, C. K., **Mechanism of electrical conductivity in nickel-iron ferrite,** *IEEE Trans. Magnetics* **MAG-4,** No. 3, 460-464 (Sept. 1968).

Key words: Conductivity; ferrites; Hall mobility; thermal emf; transition metal oxides.

Measurements of the frequency dependence of the dielectric conductivity, Hall mobility and thermal emf as a function of temperature on polycrystalline $Ni_{0.6}Fe_{0.4}Fe_2O_4$ indicate that this data can be interpreted in terms of the band model. Previous analyses of the semiconductor properties of ferrites according to the hopping model assume that the number of carriers, n, is identical with the concentration of divalent iron ions. Hall measurements indicate that this is not the case here and that n is best described by the equation

$$n^2=(N_D-n)N_o m^*/m^{3/2}g^{-1}\exp\text{-}E_D/kT.$$

Assigning a value of 2 to g, m^*/m is 9.3 and E_D is 0.034 eV.

The temperature dependence of the dc conductivity is considerably different from that of the ac conductivity. This difference is found for polycrystalline $Ni_{0.6}Fe_{0.4}Fe_2O_4$ and $LiFe_5O_8$ as well as for single crystal $LiFe_5O_8$. A Wagner type relaxation associated with interfacial polarization is present in all materials, indicating that precautions must be taken in the interpretation of dc conductivity data even when single crystals are used.

The thermal emf, calculated from Hall data, shows that the measured value is considerably larger than the calculated value. This implies that the measured values might contain a contribution from the phonon drag effect.

11343. Jellison, J. C., Collier, R. S., **Fluid phase and temperature measurement with a single sensor,** (Proc. 1968 Cryogenic Engineering Conf., Case Western Reserve Univ., Cleveland, Ohio, Aug. 19-21, 1968), Chapter in *Advances in Cryogenic Engineering* **14,** Paper H-5, 322-330 (Plenum Press Inc., New York, N.Y., 1969).

Key words: Carbon; cryogenic; fluid phase; hydrogen; low-gravity; resistance thermometry; temperature; thin film.

A technique is described, which permits a single sensor to measure temperature and the presence of liquid or vapor at a specific point in cryogenic containers. This technique compensates for disturbances such as cryogen temperature variations, and it offers indication of a gas to liquid transition in a fraction of a second. Although designed and used for LH_2 instrumentation, the basic principle has been applied to LN_2 with slight modification. The system is able to discriminate liquid presence under normal and low-gravity conditions.

Optimum use of the system under low-gravity requires the development of a sensor having a fast thermal time constant, a geometry capable of repelling cryogen films from its surface, and which can be used as a resistance thermometer. Vacuum deposited thin films of carbon are discussed as a possibility for satisfying these requirements. The resistance-temperature curve for these carbon films is nearly log-log linear over a wide temperature range, providing easy calibration of the sensor, and they have good stability on aging and thermal cycling.

11344. Johnson, V. J., **A memoir of Russell B. Scott,** (Proc. CRYO/68 Conf., Chicago, Illinois, June 9-12, 1968), Chapter in *Applications of Cryogenic Technology,* R. W. Vance and H. Weinstock, eds., Introduction, pp. 1-11 (Tinnon-Brown Inc., Los Angeles, California, 1969).

Key words: Biography; career; cryogenic engineering; memoir; Russell B. Scott; talk.

This is a review of the career of Russell B. Scott as a Cryogenic Physicist and Cryogenic Engineer at the National Bureau of Standards, as given at the Cryo/68 meeting in Chicago, June 11, 1968. The memoir includes a brief mention of his early home, family, and education. A few notes are included regarding the first 22 years of his life at NBS in Washington in the Low Temperature Physics Laboratory. His career, in conjunction with the development of the cryogenic industry, is discussed in a little more detail along with the recognition he received as a Cryogenic Engineer and as Manager of the Boulder Laboratories. It can be summed up by the inscription beneath his portrait hanging in the lobby of the Cryogenic Laboratory to wit: "Russell B. Scott, April 17, 1902—September 24, 1967, Founder and former Chief of the Cryogenics Division, An internationally recognized scientist and writer who served on the staff of the National Bureau of Standards from 1928-1965."

11345. Joiner, B. L., **The median significance level and other small sample measures of test efficacy,** *J. Am. Statist. Assoc.* **64,** 971-985 (Sept. 1969).

Key words: Efficiency of tests; median significance level; significance level; statistical tests.

The concepts of the "median significance level" (MSL) and the "significance level of the average" (SLA) are introduced and some relationships among these measures and the recently introduced "expected significance level" (ESL), "average critical value" (ACV), and "median critical value" (MCV) are considered. The median significance level is defined as the median of the distribution of the observed significance level for a given alternative, and for one-sided tests is shown to be the significance level attained by the median of the test statistic. The "significance level of the average" is analogously defined for one-sided tests to be the significance level attained by the average (expectation) of the test statistic. For one-sided tests the MSL and SLA are inverse functions of Geary's MCV and ACV. Some relations between these small sample measures of test efficacy, and Pitman's and Bahadur's asymptotic measures are described. The MCV is shown to be formally related to Hamaker's "indifference quality" method of classifying acceptance sampling plans. Several simple examples are given illustrating some relationships among the several criteria.

11346. Jones, E., Yelon, W. B., Edelman, S., **Piezoelectric shakers for wide-frequency calibration of vibration pickups,** *J. Acoust. Soc. Am.* **45,** No. 6, 1556-1559 (June 1969).

Key words: Calibration; damped resonant cylinders; damping; piezoelectric shaker; stagger-tuned shaker; vibration; vibration pickup.

This paper describes a piezoelectric shaker consisting of a combination of damped resonant cylindrical elements. Material characteristics and design parameters are chosen so that the resonances of the combined elements overlap to provide "good" motion over a wide frequency range. Data from three shakers are presented to show how a suitable set of shakers can be used for calibration of vibration pickups at frequencies up to 100 kHz.

11347. Jones, M. C., Palmer, D. C., **A technique for the measurement of spectral reflectances at low temperatures in the infrared and far infrared,** (Proc. AIAA Third Thermophysics Conf., Los Angeles, Calif., June 24-26, 1968), Chapter in *Progress in Astronautics and Aeronautics.* **Vol. 21,** *Thermal Design Principles of Spacecraft and Entry Bodies,* pp. 543-557 (Academic Press Inc., New York, N.Y., 1969).

Key words: Infrared; low-temperature; measurement; spectral reflectance; stainless steel; technique.

An experimental technique is described for the measurement of normal, spectral, specular reflectance of materials at temperatures from room temperature down to a few degrees above liquid helium temperature. The reflectance of samples is measured by comparison with reference samples of ultra-high-vacuum deposited gold on glass substrates. The difficulty of maintaining sufficient parallelism between sample and reference has been overcome; also the problem of excessive delay between recording sample and reference data has been reduced. Experimental details are given and, in illustration of the technique, the reflectance of electropolished stainless steel is presented for the wavelength range 3 μm to 300 μm at 297, 77, and 10.5 K.

11348. Kamper, R. A., **Possible contribution of superconducting devices to nuclear magnetic resonance detection,** *J. Appl. Phys.* **40,** No. 5, 2163 (Apr. 1969).

Key words: Magnetometers; nuclear magnetic resonance; superconducting devices.

We discuss the possible benefits of using superconducting components in a conventional NMR detection system, and of using a superconducting magnetometer to detect the resonance by observing the change in steady state magnetization of the nuclei. It appears that the first approach is capable of improving the sensitivity of conventional techniques by one of two orders of magnitude for suitable specimens. The second would only offer an advantage if the relaxation time τ_1 is very long.

11349. Kasen, M. B., **A method for producing small grain size in super-purity aluminum,** *Trans. Met. Soc.* **AIME 245,** No. 7, 1660-1661 (July 1969).

Key words: Aluminum; grain size; recrystallization; resistivity ratio; super-purity metals.

A method has been developed for recrystallizing super-purity aluminum to produce a very small, uniformly distributed grain size. The method involves (a) introducing a very large amount of cold work at 76 K, (b) a very short time exposure in a salt bath operating at 400 °C, and (c) a water quench. Grain sizes of 30 microns mean diameter may be reproducibly obtained in aluminum having a resistivity ratio, ρ_{293K}/ρ_{4K}, in excess of 16,000.

11350. Keller, R. A., **Intersystem crossing from excited triplet states into the singlet manifold,** (Proc. Intern. Conf. Molecular Luminescence, Loyola Univ., Chicago, Ill., Aug. 20-23, 1968), Chapter in *Molecular Luminescence,* E. C. Lim, ed., pp. 453-468 (W. A. Benjamin Inc., New York, N.Y., 1969).

Key words: Fluorescence; intersystem crossing; quantum yield; triplet states.

The quantum yield for intersystem crossing from excited triplet states into the singlet manifold was estimated for several molecules by observing the intensity of the fluorescence emission which resulted from photo-excitation of metastable triplet states. For naphthalene, about one out of every million triplet-triplet excitations crossed over into the singlet manifold. Similar results were obtained for fluorene, quinoline, and isoquinoline. No emission was observed from triphenylene, phenanthrene, or carbazole. A very small signal may have been observed from benzene.

11351. Kidnay, A. J., Hiza, M. J., Dickson, P. F., **The kinetics of adsorption of methane and nitrogen from hydrogen gas,** (Proc. 1968 Cryogenic Engineering Conf., Case Western Reserve Univ., Cleveland, Ohio, Aug. 19-21, 1968), Chapter in *Advances in Cryogenic Engineering* **14,** Paper B-2, 41-48 (Plenum Press Inc., New York, N.Y., 1969).

Key words: Adsorption; hydrogen; kinetics; low temperature; methane; nitrogen.

The breakthrough curves for 4 binary mixtures (2 nitrogen-hydrogen and 2 methane-hydrogen) and one ternary mixture (nitrogen-methane-hydrogen) were measured on an activated coconut shell charcoal at 76 K and over a wide range of flow rates. The equations of Eagleton and Bliss were used to obtain gas phase and adsorbed phase mass transfer coefficients from the breakthrough curves. Comparison of the mass transfer coefficients shows that in all cases diffusion in the pores of the adsorbent is the rate controlling step. The values for the gas phase mass transfer coefficient, when converted to j_d values, are in good agreement with the general curve proposed by DeAcetis and Thodos. The breakthrough curves were also correlated using the empirical method proposed by Engel and Coull, with good results.

The results show that it is possible to predict with reasonable accuracy, the breakthrough curves of the binary mixtures using the relations of Eagleton and Bliss. The equation of Engel and Coull provides good representation of the breakthrough curves for the ternary mixture, but its empirical nature limits its usefulness.

11352. Kieffer, L. J., **The reliability of property data, or, whose guess shall we use?,** *J. Chem. Doc.* **9,** No. 3, 167-168 (Aug. 1969).

Key words: Data; information center; reliability.

Increased reliability of property data can be achieved by critical evaluation of the techniques used in making measurements. The necessity for an implementation of such evaluations are explored.

The material in this paper was presented in a talk to the Middle Atlantic Regional Meeting of the American Chemical Society, February 12-15, 1969, Washington, D.C. It does not include any new technical information.

11353. Klein, R., Scheer, M. D., **Reaction of O(^{3}P) with 2-methyl-2-pentene at low temperatures and its implication for the transition state,** *J. Phys. Chem.* 73, 1598-1599 (1969).

Key words: Low temperature chemistry; olefins; oxygen atoms.

A formulation of a new transition complex in the reaction of oxygen atoms with olefins, recently proposed, requires an interaction between O and neighboring hydrogens at the reaction site. An experimental assessment of the strength of this interaction, obtained with 2 methyl 2 pentene, shows that the interaction is indeed strong but not strong enough to prevent some H migration in the passage to final products. The ratio of addition to the two positions at the olefinic bond is in the same sense, but considerably less for O than for H.

11354. Klose, J. Z., **Transition probabilities and mean lives of the 2s$_2$ laser level in neon I,** *J. Quant. Spec. Rad. Trans.* **9,** No. 6, 881-883 (June 1969).

Key words: Atomic lifetimes; atomic spectra; atomic transition probabilities; laser; neon.

Values of sums of transition probabilities and mean lives associated with the 2s$_2$ (Paschen notation) laser level in Ne I have been determined under various theoretical assumptions and are presented in comparison with available experimental results. Also, using intermediate coupling and the Hartree-Fock-Slater approximation, the probability of the $2s_2 \rightarrow 2p^6\ {}^1S_0$ (6266.8 Å) transition was calculated and found to be 8.8×10^7 sec^{-1}. The theoretical values were found to be in agreement with an extrapolation to zero pressure of a series of line-width measurements of the 11520 Å laser transition but in disagreement with the lifetime of the 2s$_2$ level as determined from a delayed-coincidence experiment.

11355. Knoeck, J., **Vibrational spectrometric and electrochemical evidence for lanthanum(III)-nitrate complexes in aqueous solution,** *Anal. Chem.* **41,** No. 14, 2069-2071 (Dec. 1969).

Key words: Combining ratio; complex; infrared; ion selective electrode; lanthanum; nitrate; polarography; Raman.

Raman and infrared spectra of aqueous lanthanum nitrate solutions are consistent with nitratolanthanum complexes. The observation of a polarized Raman band at 1475 cm^{-1} indicates that nitrate is a bidentate ligand in these complexes. Nitrate ion selective electrode measurements show that at least two complexes of 1:1 and 1:3 lanthanum to nitrate ratio exist in aqueous solution. The formation constant of the 1:1 complex is 30.0 ± 4.0 at 25 °C. The lanthanum catalyzed reduction of nitrate at a DME appears to involve reduction of the bound nitrate in the nitratolanthanum(III) complex ion.

11356. Knoeck, J., Taylor, J. K., **Aqueous boric acid-borate-mannitol equilibria,** *Anal. Chem.* **41,** No. 13, 1730-1734 (Nov. 1969).

Key words: Borate; boric acid; combining ratio; complex; formation constant: mannitol.

Despite recent reports to the contrary, the stoichiometry of the aqueous boric acid-borate-mannitol system has been shown to involve both a 1:1 and 2:1 mannitol-borate complex. Reliable values of the formation constants of these complexes have been determined from electrometric pH measurements. Widely divergent results obtained by previous workers in this area have been shown to be largely the result of misinterpretation of experimental data rather than anomalous behavior of the system. Reliable data taken from previous work has been shown to give the same results as data obtained in this laboratory thus providing a consistent model for boric acid-borate-mannitol equilibria.

11357. Koonce, C. S., **Tunneling into low carrier density superconductors,** *Phys. Rev.* **182,** No. 2, 5407 (June 10, 1969).

Key words: Density of states; low density superconductor; semiconductor; superconducting semiconductor; superconductivity; tunneling.

A theory of tunneling between a normal metal and a low carrier density superconductor at zero temperature is developed. Because of the small Fermi energy of low carrier density superconductors and the energy dependence of the tunneling matrix elements for these junctions, the conductance vs. voltage curves are quite different from tunneling between a metal and a high density (metallic) superconductor. The tunneling displays both the voltage-dependent conductance associated with tunneling between a metal and a degenerate semiconductor and the peaks in conductance arising from the large quasiparticle density of states at voltages slightly larger than the superconducting energy gap.

11358. Kropschot, R. H., **Thermal diffusivity of powder insulation,** (Proc. 1968 Cryogenic Engineering Conf., Case Western Reserve Univ., Cleveland, Ohio, Aug. 19-21, 1968), Chapter in *Advances in Cryogenic Engineering* **14,** Paper F-4, 224-229 (Plenum Press Inc., New York, N.Y., 1969).

Key words: Cryogenics; conductivity; diffusivity; powders; thermal insulation.

The thermal diffusivity of selected powder insulations (carbon, silica-magnesia and a silica-aluminum mix) has been experimentally determined over the temperature range 76-300 K. These results were used, along with the estimated specific heat, to calculate the thermal conductivity. Good agreement is obtained between these data and thermal conductivities obtained from steady state measurements. As expected, the diffusivity of highly evacuated 50-50 weight percent silica-aluminum powder varies by a factor of three over this temperature range. These data also enhance the justification for assuming the specific heat for bulk and powdered materials to be the same in this temperature range.

Experimentally, the diffusivities were determined from transient temperature response to a step input change in temperature. Mathematical solution of the problem for constant diffusivity is known, and it is shown here that the same basic mathematical approach is valid for the case of a temperature dependent diffusivity. The experimental apparatus is briefly described and details of the experimental results and the mathematical analysis are included.

11359. Ku, H. H., Kullback, S., **Approximating discrete probability distributions,** *IEEE Trans. Info. Theory* **IT-15,** No. 4, 444-447 (July 1969).

Key words: Approximating discrete distributions; dependence trees; minimum discrimination information estimation.

The method of minimum discrimination information estimation is applied to the problem of estimating an n-dimensional discrete probability distribution in terms of lower-order marginal distributions. The procedure provides a convergent iterative algorithm. The method yields best asymptotically normal (BAN) estimates. The general procedure includes as a particular case that proposed by a method using dependence trees. An example is given.

11360. Kuriyama, M., **X-ray diffraction from a crystal containing isolated imperfections,** *Acta Cryst.* A, No. 25, 682-693 (Nov. 1969).

Key words: Anomalous absorption; contrast; diffuse scattering; dynamical diffraction; extinction; imperfect crystal; kinematical diffraction; topography.

The x-ray scattering amplitude from a crystal containing isolated imperfections is expressed in terms of the Fourier transform of the atomic displacement vectors. The amplitude contains only the local properties of the imperfections which are "seen" by the incident beam of a finite size. The disruption of the Borrmann transmitted (or diffracted) beam, the narrowing of the dynamical diffraction range and the "diffuse" scattering caused by dynamically diffracted x-rays are some of the results obtained from the scattering amplitude. The formations of black, white and black-white images in topographs are explained by the present theory. Image contrast is also discussed in terms of the thickness of the crystal.

11361. Kuriyama, M., Miyakawa, T., **Theory of x-ray diffraction by a vibrating crystal,** *J. Appl. Phys.* **40,** No. 4, 1697-1702 (Mar. 15, 1969).

Key words: Dynamical diffraction; extinction; kinematical diffraction; piezoelectricity; theory; thickness vibration; vibrational modes; x-ray diffraction.

The scattering amplitude for x-ray diffraction by a vibrating crystal is obtained. The Bragg diffracted propagators for the perfect crystal are replaced by new propagators in which the Fourier transform of the polarizability of the crystal is multiplied by $\mathbf{J}_o(\mathbf{H} \cdot \mathbf{A}_q)$ for the vibrational amplitude $\mathbf{A}_q$, as is corrected by the Debye-Waller factor in the thermal problem. The scattering amplitude contains not only dynamical scattering but kinematical scattering.

The case of ideal thickness vibration is studied in detail. The real part of the perturbed scattering amplitude is proportional to $\sin \mathrm{H} \cdot \mathrm{A}_q$ multiplied by the H-th Fourier transform of the polarizability. The transient process from dynamical to kinematical scattering, that is, a decrease in extinction, is clearly demonstrated in terms of the vibrational amplitude.

11362. Kushner, L. M., **The NBS contribution to technological measurements and standards,** *Mater. Res. Std.* **9,** No. 10, 8-10 (Oct. 1969).

Key words: Performance standards; technological measurements and standards.

Our national system of measurement incorporates physical, material and technological measurements and standards. Whereas the first two are concerned largely with enabling us to describe the physical world, technological measurements and standards are use-related and are at the interface between science and its application in industry and Government. The NBS program in technological measurements and standards is an effort to extend the principles of good measurement to the engineering fields and to the complex needs of today's society. This goal is pursued mainly through projects designed to enable the government to use technology effectively in its role as a consumer and employer of innovative resources.

With government at all levels becoming more and more involved in developing and setting standards in a variety of fields related to public health and safety, it becomes increasingly important that the standards be of such a nature that they do not hamper the introduction of new technology for accomplishing program objectives. This leads to a need to develop more fully the concept of performance requirements as the basis for standards. This must include a concern with subjective factors which of necessity enter the measurement problems as soon as man becomes part of the system to be measured.

A related phenomenon is the "systems" nature of many of our national problems. These problems to which physical scientists and engineers are now being directed are not purely technical but have large and important social and economic components. Completely new measurement criteria are required to specify the problem and provide measures of progress toward its amelioration. The development of this new measurement methodology is being undertaken in a relatively new field of applied science, systems analysis. This is a new technology for the decision making process in business, industry and government.

The NBS technological measurements and standards program attempts to support and stimulate these activities as effective means for bringing our national scientific and engineering skills to bear on current problems.

11363. Kasuda, T., **Proposed procedures for determining building heating and cooling loads for energy calculations,** *ASHRAE Symposium Bulletin*, pp. 1-75 (1969).

Key words: ASHRAE; building heating and cooling load; energy requirements.

Hour by hour calculations of heating and cooling load are essential for the accurate evaluation of annual energy requirements needed to maintain a desired thermal environment within a building. There is a need for rigorous computer algorithms in calculating the transient thermal behavior of building structures under fluctuating climatic conditions. This paper describes most up-to-date computational algorithms for solar heat gain through fenestration, transient wall-heat conduction, psychrometrics, shadow movement, and others, which are recommended for the computer calculations of hourly heating and cooling loads.

11364. LaFleur, P. D., **Activation Analysis Section at the National Bureau of Standards, Washington, D.C., U.S.A., Laboratory of the Issue,** *J. Radioanalytical Chem.* **3,** No. 1-2, 127-133 (July 1969).

Key words: Activation analysis; Cockcroft-Walton neutron generator; LINAC; radiochemical separations; reactor; standard reference material.

The history and facilities of the Activation Analysis Section, Analytical Chemistry Division of the National Bureau of Standards are described. The Section is divided into three projects, each having application to a specific irradiation source and a project in radiochemical separations. Several examples of work in progress and of past accomplishments are included, as well as planned activities in the future.

11365. LaFleur, P. D., **Determination of molybdenum in steels and biological materials by activation analysis,** *Radiochem. Radioanal. Letters* **1,** No. 3, 225-229 (July 1969).

Key words: Activation analysis; biological materials; hydrogen bis(2-ethylhexyl) phosphate; molybdenum; radiochemical separations; steels.

A procedure for determining molybdenum by activation analysis in steels and biological matrices is described. The procedure involves a chemical separation of molybdenum by solvent extraction using the reagent hydrogen bis(2-ethylhexyl) phosphate, and subsequent back extraction with HNO_3-H_2O_2. Using the procedure as described precisions of 1-2 percent (at the 95% confidence level) are possible and 3-4 percent are routine.

11366. Lamb, V. A., **Electroplating with current pulses in the microsecond range,** *Plating* **56,** No. 8, 909-913 (Aug. 1969).

Key words: Electroplating with current in microsecond pulses; pulse plating.

Exploratory experiments were carried out on electrodeposition of copper and silver by use of pulsed direct current, with pulse periods from 0.1 to 50 microsecond and with very high current density. The microstructure and hardness of copper deposits made under these conditions were not significantly different than those of deposits plated under conventional conditions. Possible reasons are discussed. Current efficiency of copper deposition was low with the shortest pulses, but remained high for deposition of silver. Two experiments relating pulse duration to "reaction time" for the electrode reactions are described.

11367. LaVilla, R. E., Mendlowitz, H., **Optical properties of germanium,** *J. Appl. Phys.* **40,** No. 8, 3297-3300 (July 1969).

Key words: Electron energy losses; germanium; $M_{IV,V}$ edge; optical constants; oscillator; strengths; sum rules; vacuum ultraviolet.

The set of optical constants of germanium reported by Marton and Toots, from 8 to 25 eV, have been assessed, and found to be consistent to within ±5 percent. An extension of the n and k values up to photon energy of 100 eV using Hunter's k values also has been studied. The analysis consisted of an internal consistency check by applying the Kronig-Kramers dispersion relations to the optical constants and an evaluation and study of the optical and electron oscillator strength distributions. From an application of the general sum rules to the oscillator strength distribution, the computed effective number of electrons per germanium atoms suggests a redetermination of the k values in the spectral region covered by Hunter.

11368. Lehner, J., Newman, M., **On Reimann surfaces with maximal automorphism groups,** *Glasgow Math. J.* **8,** Part 2, 102-112 (July 1967).

Key words: Automorphisms; Fuchsian groups; modular group; Riemann surfaces.

Families of Fuchsian groups with associated Riemann surfaces having maximal automorphism groups are constructed, by a method which goes from the noncompact case to the compact case.

11369. Leiss, J. E., Penner, S., Rose, J. E., Broberg, J. B., **Transient beam loading in electron linear accelerators,** (Proc. 1969 Particle Accelerator Conf., Washington, D.C., March 5-7, 1969), *IEEE Trans. Nucl. Sci.* **NS-16,** Part 1, No. 3, 1027-1030 (June 1969).

Key words: Electron; energy loss; linear accelerator; short pulse; transient beam-loading; waveguide.

An experiment has been devised to measure directly the beam loading in electron linear accelerators operating with very short beam pulses. A well momentum analyzed and phase bunched electron beam is sent through either an unexcited waveguide or a vacuum pipe. Electron energy loss due to beam loading in the waveguide is detected by measuring the resulting energy shift of elastically scattered electrons with the NBS electron scattering spectrometer. Energy shifts of a few parts in 10^5 can be measured at 60 MeV. Measurements made to date at 61 MeV and for beam pulse lengths of 5, 10, and 20 nanoseconds appear to confirm the existence of enhanced beam loading relative to the usual nondispersive linac theory. An attempt is made to compare the measurements to theoretical estimates of this enhancement.

11370. Levin, I. W., Abramowitz, S., **Vibrational spectra and force field for ruthenium tetroxide,** *J. Chem. Phys.* **50,** No. 11, 4860 (June 1, 1969).

Key words: Coriolis constant; force field; infrared; isotopic shift; ruthenium tetroxide; vibrational amplitude; vibrational spectra.

Measurement of the infrared gas-phase spectrum of the ν_3 vibration for RuO_4 provides values for both the Coriolis zeta constant ζ_3 and the isotopic frequency shift $\Delta\nu_3$ for the ^{101}Ru-^{102}Ru exchange. These data, in addition to the vibrational amplitudes l(Ru-O) and l(O-O), serve as constraints in specifying unique force fields for the F_2 symmetry species of RuO_4. Agreement among the sets of force constants separately determined by the supplemental information confirms the potential function for this system.

11371. Logan, H. L., **Studies of hot salt cracking of the titanium 8 percent-Al-1 percent Mo = 1 percent V alloy,** *Proc. Ohio State Stress Corrosion Symp., Ohio State University, Columbus, Ohio, September 11-15, 1967,* pp. 662-672. (National Association of Corrosion Engineers, Houston, Texas, 1969).

Key words: Hot salt cracking; LiCl-KCl eutectic; stress-corrosion; titanium oxides; Ti-8-1-1 alloy.

Two approaches to the problem of hot salt cracking of the titanium alloy are reported. In the first of these the susceptibility of the alloy to cracking in contact with a number of chlorides was studied. Only NaCl, LiCl and a molten eutectic mixture of LiCl and KCl were found to severely crack stressed specimens exposed in air at 800 °F.

In the second phase of the program the effects of environments on the alloy in contact with NaCl were investigated. Data indicate that the oxide or series of oxides formed on the alloy surface were important in determining whether specimens developed stress-corrosion cracks.

Data also indicate that little or no chlorine was produced in the corrosion reaction.

11372. Lutz, G. J., LaFleur, P. D., **Determination of yttrium in rare earths by photon activation analyis,** *Talanta* **16,** 1457-1460 (1969).

Key words: Coincidence spectrometry; photon activation analysis; rare earths; yttrium.

The determination of yttrium in the presence of large amounts of the rare earths by the thermal neutron reaction $^{89}Y(n,\gamma)^{90}Y$ is complicated because of frequent problems of sample self shielding from major constituents of the sample and the difficulty of separating ^{90}Y, a pure beta emitter, from other elements which are very similar chemically.

A nondestructive photon activation analysis method has been developed for this determination. Bremsstrahlung from a 35-μA beam of 35-MeV electrons induces the photonuclear reaction $^{89}Y(\gamma,n)^{88}Y$. Optimum sensitivity is obtained by coincidence counting of the 0.90 and 1.83 MeV gamma rays associated with the decay of ^{88}Y. The detection limit is less than one microgram of yttrium.

11373. McBee, C. L., Kruger, J., **Ellipsometric-spectroscopy of films formed on metals in solution,** *Surface Sci.* **16,** 340-352 (1969).

Key words: Ellipsometry; iron; optical constants; passive films; spectra.

The computational problems involved in the analysis of "ellipsometric-spectroscopic" data are considered, including the existence of multiple values of the optical constants for a single wavelength.

Suggestions are made for eliminating the extra values. Examples of pertinent experiments to study corrosion processes are given for passive films grown on single crystals of iron in sodium borate-boric acid solution.

11374. McCaa, W. D., Jr., Nahman, N. S., **Frequency and time domain analysis of a superconductive coaxial line using the BCS theory,** *J. Appl. Phys.* **40,** No. 5, 2098-2100 (April 1969).

Key words: BCS theory; superconductive lines; time and frequency response; two-fluid model.

A miniature superconductive lead-teflon-niobium coaxial line has been analyzed in terms of the complete BCS theory of superconductivity. The surface impedance of both superconductors, the line attenuation and the picosecond step responses have been calculated for a temperature of 4.24 K. The dielectric has been assumed lossless.

In addition, the frequency and time domain responses obtained with the BCS theory are compared with those predicted for the same line parameters by the two-fluid model.

11375. McNesby, J. R., **The photochemistry of Jupiter above 1200,** *J. Atmospheric Sci.* **26,** No. 3, 594-599 (May 1969).

Key words: Ammonia; Jupiter; methane; photochemistry; vacuum ultraviolet.

Jovian photochemistry is shown to consist of four zones: (1) Photolysis of methane at 1216 Å and a total pressure of about 10^{-6} atmospheres and 130 km above the ammonia cloud top; (2) Photolysis of ammonia at 1700-2200 Å and a total pressure of about 10^{-4} atmospheres at 100 km; (3) Photolysis of both methane and ammonia at 1350-1450 Å at 100 km; and (4) Photolysis of ammonia at 1450-1700 Å around 10^{-2} atmospheres at 60 km. No photolysis occurs below this level. The large excess of hydrogen suggests that all radicals ultimately react with hydrogen. the net result being production of H atoms. It is concluded that complex C-H-N molecules are not formed in Jovian photochemistry because of the reducing atmosphere. Methane and ammonia persist in the atmosphere because there is no mechanism available for their disappearance.

11376. Madey, T. E., Yates, J. T., Jr., **Temperature effects in desorption by electron impact: molecular vibrations in the chemisorbed layer,** *J. Chem. Phys.* **51,** No. 3. 1264-1265 (Aug. 1, 1969).

Key words: Chemisorption; desorption; electron impact; molecular vibration; neutralization; oxygen; tungsten; (110) tungsten.

The method of desorption by electron impact is used to study oxygen chemisorbed on a (110) tungsten crystal. The positive ions desorbed from the crystal are energy-analyzed using a hemispherical retarding potential analyzer, and the resulting ion energy distribution (IED) is observed. The shape of the IED is related to the population of the various vibrational states of those adsorbed species which produce positive ions on electron impact, and to their associated vibrational wave functions. A crude form of surface spectroscopy may therefore be carried out by measuring the change in shape of the IED with temperature and inferring the change in population of the first excited vibrational state of the (surface-oxygen) oscillator. The frequency obtained in this way is ~950 cm^{-1} for the β_1 oxygen state; unequivocal identification of the oscillator as a W–O stretch or an O–O stretch is not possible.

The total positive ion yield from the surface decreases with increasing temperature. This is interpreted as arising from increase of the neutralization rate with increasing temperature.

11377. Madey, T. E., Yates, J. T., Jr., **The measurement of sticking coefficients at high temperature using the isotopic mixing method,** (Proc. Sixth Intern. Symp. Rarefied Gas Dynamics, Cambridge, Mass., July 22-26, 1968), Chapter in *The Measurement of Sticking Coefficients at High Temperatures Using the Isotopic Mixing Method* **II,** 1345-1348 (Academic Press Inc., New York, N.Y., 1969).

Key words: Carbon monoxide; high temperature; isotopic mixing; molybdenum; nitrogen; rhenium; sticking coefficient; tungsten.

The reactive sticking coefficients for CO on Re and N_2 and CO on W have been determined at high temperatures and low coverages by studying the surface reactions: $^{14}N_2$ + $^{15}N_2$, $2\,^{14}N^{15}N$ and $^{12}C^{18}O$ + $^{13}C^{16}O$, $^{12}C^{16}O$ +k $^{13}C^{18}O$. At T > 1500 K, is nearly unity for CO on W and Re; ~.01 for N_2 on W.

11378. Mahler, R. J., **Interaction of Gunn domains with the Ga^{71} nuclei in GaAs,** *Appl. Phys. Letters* **14,** No. 9. 277-279 (May 1, 1969).

Key words: Gunn effect; nuclear magnetic resonance; time dependent electric field gradients.

The application of an electric field of more than 3.2kV/cm across n-type GaAs results in the formation of high voltage approximately triangular domains which travel across the sample with a frequency determined by the length of the sample. A Ga^{71} nuclear spin transition frequency was brought within the domain frequency bandwidth and an interaction between the domains and the nuclei was observed.

11379. Maki, A. G., Jr., **Vibrational spectroscopy,** *Ann. Rev. Phys. Chem.* **20,** 273-292 (1969).

Key words: Absorption spectra; infrared; instrumentation; potential functions; spectroscopy; vibration.

A review is given of the recent scientific literature on the subject of vibrational spectroscopy. Topics which are covered include instrumentation, gas phase spectra including band contour calculations, condensed phase spectra, and vibrational potential functions.

11380. Mandel, J., **A method for fitting empirical surfaces to physical or chemical data,** *Technometrics* **II,** No. 3, 411-429 (Aug. 1969).

Key words: Curve fitting; data analysis; empirical fitting of curves and surfaces; model, mathematical; response surface; surface fitting; two-way tables.

This paper presents an illustration of a recently developed method of surface fitting. Data on the specific volume of two types of rubber, measured at various temperatures and pressures, are used to establish empirical relationships between specific volume, temperature, and pressure.

An important feature of the method is that, to a considerable extent, it evolves the model from the data. Another basic feature is that it reduces the problem of surface fitting to that of fitting a few functions of one variable each.

11381. Mangum, B. W., Soulen, R. J., Utton, D. B., **Magnetic ordering in cerium trichloride at low temperatures,** *Proc. XI Conf. Low Temperature Physics, St. Andrews, Scotland, Aug. 21-28, 1968,* **2,** 1361-1363, Paper C10.9 (University of St. Andrews, Scotland, 1968).

Key words: Dilution refrigerator; low temperature; magnetic ordering; nuclear quadrupole resonance; nuclear resonance; thermometers.

We have used the nuclear quadrupole resonance (NQR) of ^{35}Cl as a means of detecting the onset of long range magnetic ordering in $CeCl_3$. A $^3He-^4He$ dilution refrigerator was used to attain the low temperatures, CMN was used as a thermometer and the nuclear resonance was detected with a Robinson oscillator. The ^{35}Cl pure quadrupole resonance line at 4.32 MHz was observable down to 0.110 K. The signal intensity was inversely proportional to the temperature above 0.20 K. The signal to noise ratio at 0.15 K was greater than 100:1. An unsuccessful search was made for nuclear resonances in the frequency range 3.47-5.18 MHz at 0.054 K which was our lowest operating temperature. We conclude that the specific heat anomaly at 0.268 K, reported by Keen et al., is not due to long range, but rather short range, magnetic ordering. Calculations show that any static arrangement of the cerium spins will result in a magnetic field at the chlorine site. A field of 3 oersteds (1 oe $=(4\pi)^{-1}10^3$AM^{-1}) would produce a measurable effect on the NQR signal; none was observed. Although the disappearance of the signal below 0.110 K indicates the presence of an appreciable magnetic field at the chlorine site, the present measurements do not permit the assignment of a long range magnetic ordering temperature.

11382. Mangum, B. W., Thornton, D. D., **Nuclear relaxation measurements of ^{35}Cl in PrCl$_3$,** *Phys. Rev. Letters* **22,** No. 21, 1105-1107 (May 26, 1969).

Key words: Antiferromagnet; NMR; NQR; nuclear spin-spin relaxation; nuclear spin-lattice relaxation; PrCl$_3$.

We have made spin-spin, T_2, and spin-lattice, T_1, relaxation measurements of ^{35}Cl in PrCl$_3$ from 4.2 to 0.08 K. T_1 and T_2 show unusual temperature dependences in both the paramagnetic and antiferromagnetic states.

11383. Marcus, M., Newman, M., **Doubly stochastic associated matrices,** *Duke Math. J.* **34,** No. 3, 591-598 (Sept. 1967).

Key words: Associated matrices; compounds; doubly stochastic matrices; induced powers; tensor products.

It is proved that the associated matrix K(A) is doubly stochastic if and only if A is a scalar multiple of a permutation matrix, unless K(A) is a Kronecker power. In this case K(A) is doubly stochastic if and only if A is a scalar multiple of a doubly stochastic matrix.

11384. Margoshes, M., **Remarks on linearization of characteristic curves in photographic photometry,** *Appl. Opt.* **8,** No. 4, 818 (April 1969).

Key words: Arrak transform; Baker transform; emulsion calibration; Kaiser transform; photographic emulsions; Sampson transform; Seidel transform; spectrochemical analysis.

A discussion is given of the transformation $\Delta = \log(10^D\text{-}1)$, where $D = \log(1/T)$ and T is the transmittance of the photographic image, recently rediscovered by de Vaucouleurs, who claimed that Δ is a linear function of the relative exposure, log(E), over the range of values of D which are of interest. It is pointed out that this transform has been independently discovered three or more times, and that it is well known in spectrochemical analysis as the Seidel transform. Previously published and new data are cited to illustrate that Δ is only rarely a linear function of log(E). Other transforms are noted which do appear to give a linear relation with log(E) in many cases.

11385. Margoshes, M., Rasberry, S. D., **Application of digital computers in spectrochemical analysis—computational methods in photographic microphotometry,** *Spectrochim. Acta* **24B,** 497-513 (Jan. 14, 1969).

Key words: Computers; microphotometry; photographic emulsion; photographic photometry; programs; spectrochemical analysis.

A new method is described for calibration of photographic emulsions and conversion of microphotometer readings to relative intensities on a digital computer with special application to spectrochemical analysis. The method for emulsion calibration replaces graphical procedures by a numerical method which is well suited for digital computations. The method of computation and its underlying assumptions are described, and results are given of tests of the procedure. It is recognized that the entire experimental arrangement is being calibrated, not merely the photographic emulsion, and it is shown how malfunctions of the microphotometer which affect the calibration can be recognized from the output of the computer. The program for conversion of microphotometer readings to relative intensities provides for several alternate calculations, including selection of the proper calibration parameters according to the wavelength of the line when these data are supplied for more than one wavelength region, as well as correction for step and background where required. The program is written to provide for automatic selection of the required alternative calculation, based on preliminary analysis of the input data.

11386. Margoshes, M., Rasberry, S. D., **Fitting of analytical functions with digital computers in spectrochemical analysis,** *Anal. Chem.* **41,** 1163-1172 (Aug. 1969).

Key words: Analytical curves; analytical functions; emission spectrometry; fluorescence spectrometry; spectrochemical analysis; statistics; x-ray.

Two procedures are described for fitting spectrometric analytical functions on a digital computer and conversion of instrument readings to element concentrations. The first procedure is intended for computers giving rapid response, and particularly those which can operate in the conversational mode. During the running of the program the user decides on the equation to be used and whether data for any standards are to be rejected. The second procedure is intended for use on batch-loading computers; these decisions are incorporated in the program. Results are given of the use of both procedures. The occasional failures of the procedures are discussed, and methods are described for detecting such failures. A discussion is given of a method for including an estimate of the uncertainty of the analytical function in the estimated analytical error.

11387. Marinenko, G., **On the atomic weight of potassium,** *Talanta* **16,** 1339-1340 (1969).

Key words: Atomic weight; potassium.

A brief survey of data is made, which indicates the possibility that the internationally accepted value for the atomic weight of potassium (39.109) is too high. Additional experimental evidence is brought to light, which also supports the above conclusion.

11388. Marinenko, G., Champion, C. E., **Difference between the inflection point and the equivalence point in coulometric titrations of weak acids,** *Anal. Chem.* **41,** No. 10, 1208-1211 (Aug. 1969).

Key words: Boric acid; equivalence point; inflection point; Roller equation.

Mannitoboric acids of varying pK_a were successfully used to test independently the validity of the Roller equation for evaluation of the error due to noncoincidence of the inflection point and the equivalence point of acid base titration. The use of mannitoboric acid in media of different mannitol concentrations has provided the first test of the Roller equation under conditions where both parameters, c and K_a, are varied for a single acid of known stoichiometry. Moreover, the applicability of the Roller equation to complex systems such as boric acid-mannitol has not been established prior to this investigation.

11389. Marron, B. A., Tauber, S. J., **Evolution of a general computer-based information system from pharmacological requirements,** *Proc. Conf. 32nd Annual Meeting of the American Society for Information Science, San Francisco, California, Oct. 1-4, 1969,* **6,** 223-230 (Greenwood Publ. Corp., Westport, Conn., 1969).

Key words: Chemical data; computers; information retrieval; information storage; information systems; parameter control; pharmacological data.

A general information storage and retrieval system capable of handling most kinds of information by parameter control is described. The system is characterized by user description of data processing requirements and the capability of attaching modules for handling special processing problems. A specific implementation of the system for representative data types taken from chemistry and pharmacology is detailed.

11390. Martin, W. C., Sugar, J., **Perturbations and coupling in the d^9sp configurations of Cu I, Zn II, Ag I, Cd II, and Tl III,** *J. Opt. Soc. Am.* **59,** No. 10, 1266-1280 (Oct. 1969).

Key words: Atomic spectra; cadmium; copper; energy levels; energy parameters; silver; thallium; zinc.

Application of intermediate coupling theory to $3d^94s4p$ in Cu I and Zn II revealed perturbations which could not be due to configuration types $3d^{10}nl$. The $3d^94s4p$ levels except $4s4p(^1P^\circ)3d^9$ $^2P^\circ$ were then fitted by including interaction with $3d^84s^24p$. Initial values for the configuration interaction parameters were based on M. Wilson's Hartree-Fock calculations, and energy parameters for $3d^84s^24p$ (not known experimentally) were fixed at values based on related spectra. The results show that this interaction accounts for the major distortions of $3d^94s4p$ in Cu I and Zn II. The resulting interaction parameter values appear consistent with Roth's values for related iron-group spectra. The discrepancies between calculated and experimental positions for $(^1P^\circ)3d^9$ $^2P^\circ_{1/2,\,3/2}$ are qualitatively consistent with known $3d^{10}np$ $^2P^\circ$ series perturbations in Cu I, Zn II. Calculations without interaction for $4d^95s5p$ in Ag I and Cd II indicate interaction with $4d^85s^25p$ weaker than the corresponding interaction in the Cu I sequence. The levels of Tl III ($5d^96s6p + 5d^{10}7p$) were fitted with configuration interaction. One experimental d^9sp level is rejected in Zn II, Ag I, and Tl III. Corresponding new levels are found for Zn II and Ag I. Leading eigenvector components for the d^9sp levels in the $[sp(S_IL_I),d^9]SL$ and $[sp(S_IL_I)J_I,(d^9)J_{II}]J$ coupling schemes are given for all five spectra. The Tl III levels are assigned J_IJ_{II} names as most appropriate.

11391. Martin, W. C., Tech, J. L., Wilson, M., **Note on the $3p^54s3d$ configuration in neutral potassium (K I),** *Phys. Rev.* **181,** No. 1, 66-69 (May 5, 1969).

Key words: Absorption spectrum; autoionization; atomic energy levels; electron configuration; potassium.

Intermediate coupling matrices for p^5sd were diagonalized with energy parameters based on restricted Hartree-Fock wavefunctions for K I $3p^54s3d$. The resulting energies and Russell-Saunders percentage compositions for the levels are given. The average energy of the configuration was taken as 170644 cm^{-1}, the baricenter position relative to $3p^64s$ as calculated by the Hartree-Fock method. Four autoionization lines previously observed in the vacuum ultraviolet absorption spectrum of K I are classified as transitions to levels of this configuration. An approximate correction of -3400 cm^{-1} to the above baricenter is thus obtained, and predicted positions for six other transitions to $3p^54s3d$ expected below 600 Å are given. The doublet $3p^64s$ $^2S_{1/2} \rightarrow 3p^53d(^1P^\circ)4s$ $^2P^\circ_{1/2,\,1\,1/2}$ (calculated position ~ 480 Å) is predicted to absorb most of the oscillator strength of the array. The level percentage compositions also serve to confirm a conclusion of Sprott and Novick that the $^4D_{3\,1/2}$ level observed by them does not belong to $3p^54s3d$. Calculated positions for $3p^54s3d$ and $3p^54s4p$ are consistent, within the approximations, with the conclusion of Sprott and Novick that $3p^54s3d$ $^4F^\circ_{4\,1/2}$ and $3p^54s4p$ $^4D_{3\,1/2}$ are not separated by more than ~ 0.15 eV.

11392. Mason, S. T., **Dependence of the phase shift on energy and atomic number for electron scattering by atomic fields,** *Phys. Rev.* **182,** No. 1, 97-101 (June 5, 1969).

Key words: Atomic number; central potential; electron scattering; phase shift; Z-dependence.

Phase shifts of s-, p-, d-, and f-electrons scattered elastically by a potential appropriate to singly charged positive ions have been calculated for energies ranging up to 2 Rydbergs above threshold and for selected elements throughout the periodic system. The results are discussed in terms of characteristics of the model potential.

11393. Matarrese, L. M., Wells, J. S., Peterson, R. L., **EPR spectrum of Fe^{3+} in synthetic brown quartz,** *J. Chem. Phys.* **50,** No. 6, 2350-2360 (Mar. 15, 1969).

Key words: Amethyst; electron paramagnetic resonance; ferric ion; quartz; synthetic brown quartz.

A detailed description is given of the EPR spectrum of Fe^{3+} in synthetic brown quartz (the so-called I center, presumed to be interstitial). There are three, equally populated, inequivalent sites differing only in the orientation of their principal axes, which coincide with the three two-fold axes of quartz. The values of the Hamiltonian parameters that fit the data best are: $g = 2.0039 \pm 0.0003$, $C_{20}(\equiv D) = 734.1$ G, $C_{22}(\equiv(6^{1/2}/2)|E|) = 401.3$ G, $C_{40} = 2.5$ G, $C_{44} = 1.65$ G, $\lambda_{22} = 91.0°$, $\lambda_{44} = 71.5°$. The meaning of the latter two values is that lobes of the V_{22} and V_{44} parts of the crystal-field potential point 1° and 26.5°, respectively, from the optic axis of quartz. The occurrence of irregular off-axis extrema of the line positions when the magnetic field is directed in the vicinity of the optic axis precludes the assignment of magnetic axes of the paramagnetic center in the usual way. All features of the spectrum are predicted accurately by machine calculations based on the derived Hamiltonian. Although the data are not conclusive evidence, they are believed to be more consistent with an assignment of the I center to a substitutional site.

11394. Maximon, L. C., **Comments on radiative corrections,** *Rev. Mod. Phys.* **41,** No. 1, 193-204 (Jan. 1969).

Key words: Corrections, radiative; electron scattering; essential elements; radiative corrections.

We present a review of the literature on radiative corrections to electron scattering, a summary of the essential elements of the theory in a manner hopefully useful to experimenters, and comments on certain aspects of the subject that need further investigation.

11395. May, L., Spijkerman, J. J., **On the relationship between Mössbauer spectroscopy and the nuclear magnetic resonance of organotin compounds,** *J. Chem. Phys. Letter to the Editor* **46,** No. 8, 3272-3273 (Apr. 15, 1967).

Key words: Mössbauer spectroscopy; nuclear magnetic resonance; organotin compounds; relationship.

A relationship between the Mössbauer Spectroscopy chemical shift and the nuclear magnetic resonance coupling coefficient has been obtained for organotion compounds. By partitioning the total s-electron density at the tin nucleus in terms of the ligand contributions, the MS chemical shift can be calculated from the NMR coupling coefficient. This model was tested for the methylstannanes by a least square fit of the Mössbauer and NMR data. The fit was within the experimental error. The calculations also provided the ligand contribution to the total s-electron density at the tin nucleus, which explained the absence of a quadrupole splitting.

11396. Melmed, A. J., **Single-specimen FEM-LEED studies: carbon on tungsten,** *J. Appl. Phys.* **40,** No. 5, 2330-2334 (Apr. 1969).

Key words: Carbon on tungsten; field emission microscopy; low-energy electron diffraction; surface study.

Field-electron microscopy and low-energy-electron diffraction can be used in a complementary manner. A method of making such a direct combination on a single specimen is described and applied to a study of the problem of carbon contamination of tungsten surfaces. It is shown that, within the sensitivity of the apparatus used, carbon may be present and undetected by LEED on a (nonperfect) (011)-oriented W LEED specimen.

11397. Melmed, A. J., **Surface characterization by ellipsometry low-energy electron diffraction, and field-electron microscopy,** (Proc. Conf. Third Battelle Memorial Institute Materials Science Colloquium, Kronberg, Germany, May 6-11, 1968), Chapter in *Molecular Processes on Solid Surfaces,* pp. 105-127 (McGraw-Hill Book Co., Inc., New York, N.Y., 1969).

Key words: Ellipsometry; field-emission; low-energy-electron diffraction; microscopy; optical constants; oxidation; surface characterization.

Two types of experiments are described. In the first ellipsometry and LEED are combined in a study of the room temperature interaction of oxygen with (011)-oriented tungsten. Based on published interpretations concerning the LEED aspects of this experiment, the ellipsometer is shown to be capable of detecting small fractions of a monolayer of adsorbed oxygen, and the average sticking probability for oxygen is estimated to be 0.2 or 0.4 for the first half monolayer of oxygen atoms. Inability to completely understand the ellipsometry data is encountered and is attributed to inadequacy of existing theory to cope with phenomena occurring in the sub-monolayer coverage range. In the second type experiment a technique is introduced which enables FEM and LEED observations to be made on a single specimen with reasonable assurance that the entire specimen undergoes the same thermal and environmental history. Oxidation of tungsten and the adsorption and removal of carbon on tungsten are used to demonstrate surface characterization with this FEM-LEED combination.

11398. Mendlowitz, H., **Calculated transition array for the configurations $3d^2$-3d4p in Ti** III, *Astrophys. J.* **158,** 385-388 (Oct. 1969).

Key words: Configurations $3d^23d4p$; Ti III; transition strengths.

An intermediate coupling calculation has been carried out on the line strengths for the transitions between the configurations $3d^2$ and 3d4p in Ti III.

11399. Menis, O., Rains, T. C., **Determination of arsenic by atomic absorption spectrometry with an electrodeless discharge lamp as a source of radiation,** *Anal. Chem.* **41,** No. 7, 952-954 (June 1969).

Key words: Arsenic; atomic absorption; electrodeless; extraction-displacement reaction; standard reference materials; 4i.j and selenium 726.

The determination of arsenic in cast iron and high-purity selenium metal by atomic absorption spectrometry was facilitated by the extraction of the arsenic with diethylammonium diethyldithiocarbamate (DDDC) followed by a stripping process from the organic phase by displacement reaction. In addition, the high background absorption of arsenic radiation encountered in various oxidant-fuel systems was overcome with an argon (entrained air)-hydrogen flame. The electrodeless discharge lamp was found to be an excellent high intensity source of radiation for use in atomic absorption in the far ultraviolet region. The detection limits for arsenic in an aqueous medium free of interfering cations was 0.1 μg/ml.

11400. Menke, J. L., **Beam monitoring at the NBS linac—energy, positioning, current, charge,** (Proc. 1969 Particle Accelerator Conf., Washington, D.C., March 5-7, 1969), *IEEE Trans. Nucl. Sci.* **NS-16,** Part 1, No. 3, 921-922 (June 1969).

Key words: Beam current; beam energy; beam position; ferrite coils; integrator.

We describe some of the beam monitoring systems used at the NBS Linac. These include an energy display system using a pulsed magnet with 200 scanned-gate electronic readout. Shielding and electronics for use with ferrite loaded position and current monitors are discussed; and the use of a fast, wide-range integrator with ferrite current pick-ups is outlined.

11401. Mies, F. H., **Resonant scattering theory of association reactions and unimolecular decomposition. I. A united theory of radiative and collisional recombination,** *J. Chem. Phys.* **51,** No. 2, 787-797 (July 1969).

Key words: Absolute rate theory; association; configuration interaction; optical potential; predissociation; quantum mechanics; resonance scattering; scattering theory; unimolecular kinetics.

A complete quantum mechanical theory of unimolecular kinetics and of predissociation is developed using a generalized version of Fano's Theory of Resonant Scattering. An important feature of the theory is that it treats the irreversible couplings between the activated molecules and either the photon field (predissociation) or the inelastic collisions with bath molecules (unimolecular decomposition) by means of an optical potential, and leads to very concise and certainly in the case of predissociation exact results.

The final form of the rate expressions are expressed in a form resembling the Eyring Absolute Rate Theory (ART), with the important result that explicit theoretical expressions are given for the "transmission coefficients" as a function of temperature and pressure, which in principle allows us to calculate the rates.

11402. Miller, K. J., Mielczarek, S. R., Krauss, M., **Energy surface and generalized oscillator strength of the $^1A''$ Rydberg state of H_2O,** *J. Chem. Phys.* **51,** No. 1, 26-32 (July 1969).

Key words: Born approximation; energy surface; generalized oscillator strength; Hartree-Fock; H_2O; photodissociation; Rydberg.

The energies and wave functions of the lowest singlet and triplet Rydberg states in H_2O were calculated in the expansion basis self-consistent field procedure for a single configuration. A portion of the energy surface of the $^1A''$ Rydberg state for an OHO angle of 105° was determined that shows the asymmetric dissociation of this state into ground state $H(^2S)$ and $OH(^2\Pi)$ fragments. The energy along the reaction coordinate is almost separable into a repulsion depending only on the center of mass separation and an attractive potential that depends only on the OH internuclear separation.

For the C_{2v} conformation a large basis set was used to approach the Hartree-Fock limit. Using these functions a minimum was calculated in the generalized oscillator strength for the $^1A_1 \rightarrow {}^1B_1$ transition as a function of the momentum transfer function or the electron scattering angle. This behavior was then confirmed experimentally for an energy loss of 7.4 eV with an incident electron energy of 500 eV. Such a minimum is a general characteristic of Rydberg transitions and is not an essentially molecular phenomena. The good agreement between experiment and theory indicates a reasonable fit to the Rydberg wave function by the approximate Hartree-Fock calculation.

11403. Miller, R. C., Prausnitz, J. M., **Statistical thermodynamics of simple liquid mixtures. Henry's constants,** *Ind. Eng. Chem. Fundamentals* **8,** No. 3, 449-452 (Aug. 1969).

Key words: Henry's constants; liquid mixtures; partition function; phase equilibria; statistical thermodynamics; supercritical component; van der Waals'/Percus and Yevick.

The cell-theory partition function of Eckert and Renon is useful for calculating Henry's constants for solutes provided that the temperature is well below the solute's critical. For higher temperatures a new partition function is developed based on a modified van der Waals' model. The potential energy of the solute molecule in solution is related to a perturbation of the hard-sphere radial distribution function, calculations are presented for Henry's constants for methane, nitrogen and hydrogen in several simple liquid solvents.

11404. Milligan, D. E., Jacox, M. E., **Matrix-isolation study of the infrared and ultraviolet spectra of the free radical HCO. The hydrocarbon flame bands,** *J. Chem. Phys.* **51,** No. 1, 277-288 (July 1, 1969).

Key words: Absorption; DCO; emission; force constants; formaldehyde; free radical; HCO; hydrocarbon flame bands; infrared spectrum; matrix isolation; photolysis; ultraviolet spectrum.

The photoproduction of H or D atoms from a variety of sources in a carbon monoxide matrix or in an argon matrix to which a small concentration of carbon monoxide has been added leads to the appearance of prominent ultraviolet absorptions between 2100 and 2600 Å, all of which may be assigned to HCO or DCO. Both the CO-stretching and the bending vibrational modes are appreciably excited in the transition. Evidence is presented indicating that the transition observed in the matrix experiments is the same one responsible for the hydrocarbon flame bands. Using the frequencies observed in the matrix experiments, a tentative assignment for the hydrocarbon flame bands has been proposed which is in reasonable agreement with the observed band structure of the emission system. In the upper state, the carbon and oxygen atoms of HCO are approximately singly bonded. Observation of the infrared absorption frequencies of isotopically substituted HCO in an argon matrix, has prompted reconsideration of the valence force field appropriate to ground-state HCO. Interaction between the CH-stretching and the CO-stretching modes has been found to play an important role. Factors leading to the stabilization of HCO in an argon matrix in the present experiments, in contrast to the results of previous studies, are discussed.

11405. Milligan, D. E., Jacox, M. E., **Studies of the photoproduction of electrons in inert solid matrices. The electronic spectrum of the species C_2^-,** *J. Chem. Phys.* **51,** No. 5, 1952-1955 (Sept. 1, 1969).

Key words: Acetylene; C_2 radical, C_2^- ion; cesium; electron affinity; matrix isolation; photoionization; Swan bands; ultraviolet spectrum; vacuum-ultraviolet photolysis.

The vacuum-ultraviolet photolysis of acetylene isolated in an argon matrix at 14 K in the presence of a small concentration of a photoelectron source leads to a marked enhancement in the intensity of the 5206 Å band system previously assigned to the Swan transition of C_2. Cesium atoms have been found to provide an especially abundant electron source for these studies. The vibrational band spacings observed for the 5206 Å band system agree much more closely with those recently reported by Herzberg and Lagerqvist for the 5416 Å band system of a species tentatively identified as C_2^- produced upon flash discharge through methane than with the band spacings observed in the gas phase for the Swan transition of C_2. Accordingly, it is suggested that the 5416 Å band system of the gas-phase studies and the 5206 Å band system of the argon matrix experiments correspond to the same transition. The enhancement of this band system in the presence of a photoelectron source supports the hypothesis that the species which contributes it is negatively charged.

11406. Motz, J. W., Olsen, H. A., Koch, H. W., **Pair production by photons,** *Rev. Mod. Phys.* **41,** No. 4, Part 1, 581-639 (Oct. 1969).

Key words: Electrons; pair production; photon polarization; photons; positrons; triplet production.

The present report reviews, analyzes, and integrates the various quantitative results that have been obtained for the process of pair production by photons. This summary includes a detailed review of total and differential pair cross sections with a critical evaluation of the conditions of validity and the accuracy of the results. In addition, a summary is given of the important kinematic relations and the polarization effects that occur in pair production.

11407. Mullen, L. O., Sullivan, D. B., **Fabrication of tunnel junctions on niobium films,** *J. Appl. Phys.* **40,** No. 5, 2115-2117 (April 1969).

Key words: Josephson effect; niobium; superconducting device; thin films; tunnel junctions.

High background currents, often observed in tunnel junctions when the barrier is formed by oxidizing niobium, probably stem from the fact that one oxide of niobium (NbO) is not an insulator. The fabrication process described in this paper uses an active layer of gas adsorbed on the niobium surface that reacts with the upper film (e.g. lead) and forms the junction barrier. This technique avoids the problem above and results in tunnel junctions with low background currents.

11408. Nahman, N. S., **Superconducting transmission lines—communication and power,** *Proc. 1968 Summer Study on Superconducting Devices and Accelerators, Brookhaven National Laboratory, Upton, L.I., New York, June 10-July 19, 1968,* **BNL-50155,** pp. 622-627 (1968).

Key words: Superconductive; transmission.

Reviews are given on (1) the experimental and theoretical work on S.C. signal transmission lines and (2) theoretical designs of S.C. power transmission lines. A brief exposition is presented on the constituents of a generalized data communication system. Elements of the above described topics are drawn together in a consideration of the idea of combining S.C. power and communication lines into one system.

11409. Nargolwalla, S. S., Przybylowicz, E. P., Suddueth, J. E., Birkhead, S. L., **Solution of blank problems in 14-MeV neutron activation analysis for trace oxygen,** *Anal. Chem.* **41,** No. 1, 168-170 (Jan. 1969).

Key words: Blank; Cockcroft-Walton neutron generator; "flow through" container; gamma-attenuation; geometrical correction; neutron attenuation; systematic error analysis; trace oxygen; 14-MeV neutron activation analysis.

A major difficulty in the analysis for trace oxygen by 14-MeV neutron activation analysis is the accurate determination of the oxygen contribution from the blank. If the count from the oxygen in the container is merely subtracted from the total sample-in-container count, errors greater than 100 percent in the oxygen content of the sample may result.

This work describes a procedure for accurately establishing the blank contribution. The method takes into consideration the attenuation of the activity produced in the polyethylene container by the sample during irradiation and counting. A proposed model permits corrections for the sample-in-container geometries with respect to the neutron source and detector system for different rod diameters. For metal rods, a "flow through" container propelled with nitrogen in the pneumatic transfer system was used to eliminate oxygen contribution from the container void volume. Within the precision of measurement, the experimental results agree with those predicted from theory.

11410. Nemoto, T., Beatty, R. W., Fentress, G. H., **A two-channel off-null technique for measuring small changes of attenua-**

tion, *IEEE Trans. Microwave Theory Tech.* **MTT-17,** No. 7, 396-397 (July 1969).

Key words: Attenuation; microwave; off-null technique; small attenuation changes; two-channel.

A technique is described for measuring small changes of attenuation which are not accompanied by significant changes in phase shift. It is a two-channel technique in which a small off-null output signal undergoes relatively large changes upon making small changes in a test attenuator in one of the channels.

The procedure is described and measurements from 0.01 to 0.1 decibel on a rotary vane attenuator are compared with similar measurements by a different method. Agreement is within 4 percent.

11411. Newman, M., **A diophantine equation,** *J. London Math. Soc.* **43,** 105-107 (1968).

Key words: Automorphisms; cyclotomic fields; diophantine equations; roots of unity.

An effective method for determining all rational solutions x_1, x_2, . . ., x_l of the equation $\sin\pi x_1 \sin\pi x_2 \ldots \sin\pi x_l =$ positive rational is given.

11412. Newman, M., **Some results on roots of unity, with an application to a diophantine problem,** *Aequat. Math.* **2,** No. 2/3, 163-166 (Nov. 28, 1967).

Key words: Cyclotomic fields; diophantine equations; multiplicative functions.

The principal result of this note is the determination of all rationals x, y such that $\sin\pi x \sin\pi y$ is rational.

11413. Newton, C. J., Ruff, A. W., Jr., **X-ray studies of plastically deformed silver alloys—effects due to oxygen, hydrogen, and tin solutes,** *Advan. X-ray Anal.* **12,** 316-328 (1969).

Key words: Alloys; plastics; silver alloys; x-ray studies.

Solid specimens of silver were charged at different temperatures in atmospheres of oxygen and of hydrogen. X-ray diffraction line profiles were obtained using powders filed from the treated specimens. Fourier analysis of the diffraction lines was conducted following the method of Warren. The effective particle sizes and root-mean-square strains were obtained from the line shape analysis. Stacking fault and twin fault probabilities were determined from peak-position and center-of-gravity displacements, respectively. For the purpose of comparison, two vacuum-melted silver samples and two different silver-tin alloys were studied. The stacking fault and twin fault probabilities were observed to be nearly unaffected by charging in either oxygen or hydrogen. These results are consistent with recent direct determinations of the effect of oxygen on the stacking fault energy of silver. In contrast, the rms strains and particle sizes changed significantly after charging in oxygen. A decrease in the root-mean-square strain and a corresponding increase in the particle size was found. These effects were opposite to those obtained by adding substitutional solute to silver. These findings are interpreted to indicate the effect of oxygen clustered with impurities on the dislocations and stacking faults in silver.

11414. Nimeroff, I., Schleter, J. C., **Professor Harry J. Keegan: Colorimetrist's spectrophotometrist,** *J. Appl. Opt.* **8,** No. 4, 757-761 (Apr. 1969).

Key words: Colorimetry; Keegan, Harry J.; photointerpretation; safety color codes; spectrophotometry; standards for spectrophotometers.

This paper is a tribute to Professor Harry J. Keegan (October 11, 1903 to April 19, 1968), prepared by two of his close associates at the National Bureau of Standards. The significance of his scientific and academic careers is reviewed and a substantially complete collection of references to his works is presented.

11415. O'Connell, J. S., **An isospin sum rule for photonuclear reactions,** *Phys. Rev. Letters* **22,** No. 24, 1314-1316 (June 16, 1969).

Key words: Correlations; electric dipole; isospin; photonuclear; radii; sum rule.

A relationship is derived between proton and neutron mean square radii and a pair correlation function in stable nuclei, and energy weighted sums of the electric photodisintegration cross section to the two final isospin states.

11416. O'Connell, J. S., Prats, F., **Isospin sum rules and the photodisintegration of the A = 3 nuclei,** *Phys. Rev.* **184,** No. 4, 1007-1012 (Aug. 20, 1969).

Key words: Helium-3; isospin; photonuclear; radii; sum rule; tritium.

Three sum rules for the electric dipole photodisintegration cross section of the $A=3$ nuclei are split into their final isospin components. The isospin doublet contribution to the three-nucleon breakup mode is found to be of the order of 10-20 percent and to originate primarily in the high energy region.

11417. Odom, J. V., **Problems of metric conversion,** *ASTME Vectors* **4,** No. 4, 17-19 (July/Aug. 1969).

Key words: International system of units; measurement systems; metric system; metric system study.

The increasing worldwide use of the metric system is causing problems for manufacturers of hardware items. These problems and the law that was recently enacted by Congress to study these problems and seek sensible solutions are discussed, and the background that caused the law to be enacted is reviewed.

11418. Paabo, M., Bates, R. G., **Dissociation of deuteriocarbonate ion in deuterium oxide from 5 to 50°,** *J. Phys. Chem.* **73,** No. 9, 3014-3017 (Sept. 1969).

Key words: Acidic dissociation; bicarbonate ion; carbonic acid; deuteriocarbonate ion; deuterium oxide; dissociation of acids; emf measurements; heavy water; isotope effects; thermodynamics of dissociation.

Electromotive-force measurements of cells with deuterium gas electrodes and silver-silver chloride electrodes have been used to determine the acidic dissociation constant of deuteriocarbonate ion (DCO_3^-) in deuterium oxide from 5 to 50 °C at intervals of 5 °C. In addition to the dissociation constant, the standard changes of enthalpy, entropy, and heat capacity for the dissociation process at 25 °C have been obtained. The isotope effect, $pK(D_2O) - pK(H_2O)$, for bicarbonate ion is 0.748 at 25 °C and decreases with increasing temperature. This value is significantly higher than is found for stronger acids. The entropy of ionization in deuterium oxide is smaller than that in water by 6 J K^{-1} mol^{-1}; this difference is the same as has been found for other weak acids for which isotope effects have been determined.

11419. Peiser, H. S., Wachtman, J. B., Jr., **Jump rates for point defects in special positions held by a trapping centre of cubic symmetry,** Chapter 12 in *Physics of the Solid State,* S. Balakrishna, M. Krishnamurty, and Rao B. Ramachandra, eds., pp. 207-222 (Academic Press Inc., New York, N.Y., 1969).

Key words: Crystal; cubic; jump rate; point defect; relaxation; symmetry; trapping center.

Point defects, held by a trapping center of cubic symmetry in special positions relative to symmetry elements, generally can move between equivalent sites with more than one jump rate. For all possible symmetry groups of trap and point defect all distinct paths are listed using a novel nomenclature. It is shown how such paths can give rise to relaxation phenomena by the action of external influences. For all relevant symmetry combinations we list J_{max}, the maximum, and J_{min}, the minimum number of jump rates for upsetting (or re-equalizing) the population balance between sites that are equivalent in the unstrained crystal. J_{max} often is the number of prime factors in the quotient between the orders of the point groups of the trap and the defect. J_{min} is the minimum number of operators that will raise the defect point group to that of the trap.

11420. Pella, P. A., DeVoe, J. R., Snediker, D. K., **Problems in using Mössbauer spectrometry for quantitative analysis: application to tin,** *Anal. Chem.* **41,** No. 1, 46-50 (Jan. 1969).

Key words: High resolution detector; Mössbauer; quantitative analysis; source-sample-detector geometry; tin compounds; use of filters.

Initial studies for the application of Mössbauer spectroscopy to the quantitative analysis of tin compounds are described. The effect of variables such as drift in detector response, sample thickness, and sample concentration on the spectral parameters was studied using Pd_3Sn^{119m} as a source and synthetic samples of SnO_2 in an Al_2O_3 matrix. Under controlled conditions, the reproducibility of the spectral parameters were studied for sample sizes from 3 to 122 mg of SnO_2 with a relative standard deviation (of a single measurement) for 3 replicates of 0.5 to 5 percent over this range of sample size. The data were well approximated by an exponential absorption law. Such factors as source-sample-detector geometry, use of filters, and a high resolution detector were considered in an effort to optimize the ratio of the resonant absorption intensity to the total transmitted intensity.

11421. Pfeiffer, E. R., Schooley, J. F., **Superconducting transition temperatures of Nb-doped $SrTiO_3$,** *Phys. Letters* **29A,** No. 10, 589-590 (Aug. 11, 1969).

Key words: Charge carrier density; Nb-doped $SrTiO_3$; superconductivity; transition temperature maximum; transition temperatures.

We have observed superconducting transitions in Nb-doped $SrTiO_3$ over the range of charge carrier densities $n = 0.13 - 2.2 \times 10^{20}$ cm^{-3}. A T_c maximum is observed similar to those previously observed in reduced $SrTiO_3$ specimens.

11422. Piermarini, G. J., Mighell, A. D., Weir, C. E., Block, S., **Crystal structure of benzene II at 25 kilobars,** *Science* **165,** 1250-1255 (Sept. 19, 1969).

Key words: Benzene II; high-pressure; single-crystal; structure determination; twinning.

At elevated temperatures and pressures, crystals of benzene II may be grown in the diamond-anvil high-pressure cell from either the liquidus or the solid I solid II transition. Depending upon the conditions of growth, crystals were either single or twinned. X-ray precession data were obtained from a single crystal in the high-pressure cell. Benzene II crystallizes in the monoclinic system with $a = 5.417 \pm .005$ Å (standard error), $b = 5.376 \pm .019$ Å, $c = 7.532 \pm .007$ Å, $\beta = 110.00 \pm .08°$, space group $P2_1/c$, $Z = 2$, $\rho_c = 1.26$ g.cm^{-3} for the conditions 21 °C and ~25 kbars. As only a limited amount of data were obtained, the structure was solved by generating all physically reasonable molecular packing configurations. For each configuration, structure factors and a reliability factor were calculated. This procedure produced a unique solution for the molecular packing of the benzene molecules. The final R based on 19 unique reflections is 7.6 percent. This structure was confirmed by molecular packing energy calculations.

11423. Post, M. A., **Determination of styrene-butadiene and styrene-acrylate resins in solvent type paint,** *J. Paint Technol.* **41,** No. 537, 567-580 (Oct. 1969).

Key words: Chlorinated paraffin; infrared spectroscopy; solvent type paint; styrene-acrylate resin; styrene-butadiene resin.

Styrene-butadiene and styrene-acrylate resins are determined quantitatively in solvent type paint by two methods. One, a short and convenient method, is useful in acceptance testing of Federal Specifications paints where the chlorinated paraffins 40 and 70 are used in 1:1 ratio. It involves determination of total benzene extractables and the styrene resin content therein. The latter is evaluated by measuring the 3.3 μm/3.5 μm absorbance ratio for styrene-butadiene and the 5.8 μm/3.5 μm absorbance ratio for styrene-acrylate, using the baseline method for both. The ratios are obtained from infrared spectrograms of cast films of benzene extracts. The styrene resin content then is determined from the appropriate standard curve. The second method separates the plasticizer (chlorinated paraffins) and styrene resin by Soxhlet extraction of the dried dispersed paint, first with n-pentane, which removes the plasticizers and 5-10 percent of the styrene resin, and then with benzene, which removes the remainder of the styrene resin. A combination of the two methods can be used for paints where the type and proportion of plasticizers are unknown. Methods are applicable to commercial materials.

11424. Powell, C. J., **Analysis of optican- and inelastic-electron-scattering data. Parametric calculations,** *J. Opt. Soc. Am.* **59,** No. 6, 738-743 (June 1969).

Key words: Complex dielectric constant; energy-loss interpretation; inelastic electron scattering; optical properties; parametric calculations.

Using a simple model for the complex frequency-dependent dielectric constant $\epsilon(\omega)$, calculations have been made of $-\mathrm{Im}[1/\epsilon(\omega)]$, the electron energy-loss function, as the model parameters were varied systematically in a physically-resonable range. It was found that the intensity as well as the position of structure in $-\mathrm{Im}[1/\epsilon(\omega)]$ were strongly influenced by the admixture of free-electron- and interband-transition-contributions to $\epsilon(\omega)$. Where such admixture-effects occur in real materials, it is not meaningful to identify structure in $-\mathrm{Im}[1/\epsilon(\omega)]$ as being exclusively due to plasmon excitation or to interband transitions.

11425. Qureshi, I. H., McClendon, L. T., LaFleur, P. D., **Extraction studies of the group of IIIB-VIIB elements and the lanthanides utilizing bis(2-ethyl-hexyl) orthophosphoric acid,** *Radiochim. Acta* **12,** No. 2, 107-111 (Aug. 1969).

Key words: Group IIIB-VIIB elements; HDEHP; hydrochloric acid; lanthanides; nitric acid; perchloric acid; solvent extraction.

The extraction behavior of the group IIIB-VIIB elements and the lanthanides from 1-11*M* hydrochloric, perchloric and nitric acid solutions into 0.75*M* bis(2-ethyl-hexyl) phosphoric acid solution has been studied. The group IVB elements and scandium exhibit high extraction which is independent of hydrogen ion concentration; the group VIIB elements are essentially unextracted. The extraction of some elements of group VB and VIB and of the lanthanides reaches a minimum and then increases with increasing acidity. This behavior is attributed to a change in extraction mechanism.

11426. Radziemski, L. J., Jr., Kaufman, V., **Wavelengths, energy levels, and analysis of neutral atomic chlorine** (Cl I), *J. Opt. Soc. Am.* **59,** No. 4, 424-443 (Apr. 1969).

Key words: Atomic spectra; chlorine; spectroscopy; wavelengths.

New wavelength measurements in the region from 950 to 12000 Å were combined with the infrared data of Humphreys and Paul (J. Opt. Soc. Am. **49,** 1180 (1959)) to extend the analysis of Cl I. Electrodeless discharge lamps containing $SiCl_4$, $GeCl_4$, $PbCl_2$, or chlorine gas were used to obtain wavelengths for 925 lines, of which 330 are interferometric values. The number of classified and observed lines has increased from about 550 and 780, to 1097 and 1173 respectively. Forty-three new even levels and 39 new odd levels were established, five levels rejected, and some J values and configuration assignments changed. The total number of known levels now stands at 112 odd and 128 even levels. The $3s3p^6\ ^2S_{1/2}$ was found at 85679 cm^{-1}, and new levels belonging to each of the Cl II $3p^4$ limit levels were established. Most of the new levels belong to the $3p^46p$, $3p^4nf$ n = 6 to 8, $3p^4ns$ n = 6 to 8, and $3p^4nd$ n = 4 to 8 configurations. The improved measurements and energy level values lead us to propose 108 vuv lines with uncertainties of less than 0.0015 Å as reference wavelengths. The accuracy of the series limit corresponding to Cl II $3p^4\ ^3P_2$ was improved slightly; the newly calculated value is 104591.0 ± 0.3 cm^{-1}.

11427. Rains, T. C., **Chemical aspects of atomic absorption,** *Am. Soc. Testing Mater. Spec. Tech. Publ.* **443,** 19-36 (1969).

Key words: Analysis; atomic absorption; detection limits; electrodeless discharge; interferences; nebulizer-burner; organic ligands; releasing agents; solvents.

The phenomenal growth of atomic absorption spectrometry in the past 12 years can be attributed to many factors such as the high sensitivity of the method for a large number of elements, advances in overcoming interferences, saving of time required for analysis, and the rapid improvement of instrumentation. The major interferences in atomic absorption are of a chemical nature; however, physical interferences which are associated with the chemical matrix are often present. To overcome chemical interferences and to eliminate or minimize their influences from phosphate, aluminum, titanium and any other elements producing nonvolatile compounds, high temperature flames or releasing agents are used. Also, the use of a separation and preconcentration technique often becomes necessary when determining elements at the sub-trace level. A list of organic ligands and solvents used in solvent extraction for absorption are presented as a means of preconcentration and removal of chemical interferences.

11428. Rains, T. C., **Chemical interferences in condensed phase,** Chapter 12 in *Flame Emission and Atomic Absorption Spectrometry,* J A. Dean and T. C. Rains, eds., **1,** 349-379 (Marcel Dekker Inc., New York, N.Y., June 1969).

Key words: Atomic absorption; atomic fluorescence; flame emission; flame temperature; interference; oxidant-fuel; protective chelation; releasing agent.

In flame emission, atomic absorption or atomic fluorescence spectrometry, condensed phase type of interference is observed to occur for many analytes. The degree of interference on the analyte depends upon the interferent and the various parameters associated with the production of free atoms in the flame gas. Proposed mechanisms for the interference of PO_4^{3-}, SO_4^{2-} and Al^{3+} on the alkaline-earth metals are discussed together with methods for their elimination or control. The effect of flame temperature, choice of oxidant-fuel, nebulizer-burner systems and the use of releasing or protective chelating agents are reviewed as a method to minimize the condensed phase type of interference.

11429. Rains, T. C., Menis, O., **High-precision flame emission spectrometry,** *Spectroscopy Letters* **2,** No. 1, 1-7 (1969).

Key words: Attenuator; differential flame emission; phase shifter; precision; synchronous detector.

A new technique for differential flame emission spectrometry is described. The application of this method permits the determination of lithium as a major component in a glass matrix with a precision of one part per thousand.

11430. Raveché, H. J., Green, M. S., **On the consistency of the Yvon-Born-Green hierarchy and its truncations,** *J. Chem. Phys.* **50,** No. 12, 5334-5336 (June 1969).

Key words: Closure; consistency; hierarchy; Kirkwood superposition; potential of mean force.

The assumption of truncation of the hierarchy of reduced distributions for fluids at thermodynamic equilibrium is discussed. We consider the question of whether a truncated hierarchy yields expressions which are conservative for the mean force on a molecule, in the presence of its neighbors. It is concluded that in general it does not, although the Kirkwood superposition and the infinite hierarchy do. The conclusion is reached that, unless the closure satisfies a certain condition, the truncated hierarchy in general has no solutions.

11431. Reader, J., **Optimizing Czerny-Turner spectrographs: A comparison between analytic theory and ray tracing,** *J. Opt. Soc. Am.* **59,** No. 9, 1189-1196 (Sept. 1969).

Key words: Aberrations; coma; Czerny-Turner; geometrical optics; plane grating; ray tracing; spectrograph.

The analytic theory of aberrations has been used to derive an expression for the magnitude of the comatic width of the image in the meridional plane in a Czerny-Turner spectrograph with unequal mirror radii. The calculated properties of a 4-m spectrograph with equal radii and a recently constructed 3.34-m spectrograph with unequal radii are compared with the results obtained by tracing individual rays. The agreement is excellent, in contrast to the results of Chandler, J. Opt. Soc. Am. **58,** 895 (1968). The lateral position of the grating for complete elimination of coma found experimentally with the 3.34-m instrument is also in good agreement with the theory. A correction to the $\sqrt{3}$ longitudinal grating position is given for a Czerny-Turner spectrograph which results in a flatter focal surface.

11432. Reed, R. P., **Low-temperature mechanical properties of welded and brazed copper,** (Proc. 1968 Cryogenic Engineering Conf., Case Western Reserve Univ., Cleveland, Ohio, Aug. 19-21, 1968), Chapter in *Advances in Cryogenic Engineering* **14,** Paper C-3, 83-87 (Plenum Press Inc., New York, N.Y., 1969).

Key words: Brazed; copper; low temperature; notch-tensile; tensile; welded.

The tensile and notch-tensile properties of butt-welded and overlap brazed copper plate were examined at test temperatures 300, 195, 76, and 4 K. The brazed strengths were determined for both 1/8 and 1/4 inch overlap widths. It was found that the strength and ductility of copper joints increase at lower temperatures. Also, the joint strength decreases and elongation increases as the brazed overlap width is increased.

11433. Reed, R. P., Schramm, R. E., **Lattice parameters of martensite and austenite in Fe-Ni alloys,** *J. Appl. Phys.* **40,** No. 9, 3453-3458 (Aug. 1969).

Key words: Fe-Ni alloys; lattice parameters; martensite.

The lattice parameters of the martensitic, body-centered cubic phase and the face-centered cubic phase were determined for a series of Fe-Ni alloys. Compositions ranged from pure Fe to Fe-35 at. percent Ni. Careful Debye-Scherer powder techniques and computerized calculations and error analyses were employed. The martensite lattice parameter has been precisely determined for the first time as a function of composition in Fe-Ni alloys. Results indicate that the martensite lattice parameter reaches a maxmium between 9 and 15 at. percent Ni and the room temperature lattice parameter of the face-centered cubic phase has a maximum in alloys having greater than 35 at. percent Ni. The face-centered cubic parameter was not measurable in alloys having less than 27 at. percent Ni.

11434. Reeve, G. R., **A heterodyne near-zone field-strength meter,** *IEEE Trans. Instr. Meas.* **IM-18,** No. 1, 32-37 (Mar. 1969).

Key words: Electric field strength; field, near zone electromagnetic; line, semiconducting plastic transmission; meter, radio field strength.

This paper describes a tunable field strength meter covering the 12 to 30 MHz range which can be used to measure electric intensities from 0.1 to 1000 volts/meter in the near zone of an antenna with an estimated uncertainty of ±2 dB.

The use of high resistance plastic telemetry lines enables the field to be probed without disturbance, while a novel detector circuit and meter enable a 40 dB display with minimal reading error. Laboratory and field test data on the device are presented.

11435. Robbins, R. F., Weitzel, D. H., **An automated resilience apparatus for polymer studies from −196 to +180 °C,** *Rev. Sci. Instr.* **40,** No. 8, 1014-1017 (Aug. 1969).

Key words: Dynamic properties: low temperatures; polymers; resilience.

A rebound resilience apparatus was developed to study the dynamic mechanical properties of polymeric materials from −196 to +180 °C. Resilience data at a frequency of about 3500 Hz are obtained by measuring ball velocity near the sample with a photoelectric device. Frequency of impact is estimated using a microphone pick-up. The results are recorded automatically with a data acquisition system designed for the test.

The apparatus is virtually automatic in operation, and has wide flexibility in sample configuration, temperature range, and temperature control. The results can be related to other dynamic mechanical properties data, and estimates of Young's modulus in the regions of high resilience can be performed.

11436. Roberts, D. E., **Recrystallization and melting of partially melted Stark rubber,** *Rubber Chem. Technol.* **42,** 540-546 (Mar. 1969).

Key words: Crystallized rubber; crystal size; 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.

11437. Robinson, R. A., **An isopiestic vapor pressure study of the system potassium chloride-sodium chloride in deuterium oxide solution at 25°,** *J. Phys. Chem.* **73,** No. 9, 3165-3166 (Sept. 1969).

Key words: Deuterium oxide; potassium chloride; salt mixtures; sodium chloride; solutions.

Vapor pressure measurements of the system potassium chloride-sodium chloride-deuterium oxide have been made at 25 °C and compared with similar data for the same salt system in ordinary water. There is no detectable difference in the behavior of this salt pair in the two solvents when the results are expressed on the aquamolality scale.

11438. Rockett, J. A., **Planned operation of the National Bureau of Standards Fire Research and Safety Office,** *Fire J.* **63,** No. 6, 41-43 (Nov. 1969).

Key words: Fire; research program.

The proposed program for the Fire Research and Safety Center is outlined. This consists of: (1) Statistical studies on deaths and injuries in fires and on the effectiveness of fire protection measures; (2) A study of the way in which fire grows and spreads in a building; and (3) Three programs related to fire service operations: (a) The use of Operations Research; (b) Improvement of breathing masks; and (c) A study of fire service training and education.

11439. Rubin, R. J., **Transmission properties of an isotopically disordered one-dimensional harmonic crystal,** *J. Math. Phys.* **9,** No. 12, 2252-2266 (Dec. 1968).

Key words: Crystal dynamics; defects; disordered crystals; multiple scattering; wave propogation in stochastic media.

The amplitude $\mathscr{T}_N(\omega)$ of a wave of frequency ω which is transmitted by a disordered array of N isotopic defects in a one-dimensional crystal has been investigated in the limit in which $N \to \infty$ while the overall concentration of the defects in the array remains fixed. The transmitted amplitude $\mathscr{T}_N(\omega)$ is proportional to the reciprocal of the magnitude of an Nth order determinant whose elements depend explicitly upon the spacings between defects, the incident frequency ω, and the relative mass difference $Q=(M - m)/m$ between the defect particles and the particles of the host crystal. $\mathscr{T}_N(\omega)$ is represented as $\exp[-N\alpha_N(\omega.Q,c)]$ where C is the overall fractional concentration of defects; and two types of estimates of $\alpha_N(\omega.Q.c)$ are obtained. First, assuming that the spacings between nearest-neighbor pairs of defects are independent random variables, upper and lower bounds are obtained on $\alpha_N(\omega.Q,c)$ which are independent of N. Provided that C is sufficiently small, the lower bound is positive. Second, Monte Carlo estimates of $\alpha_N(\omega.Q,c)$ are obtained in the cases $Q = 1$, $C=0.1$ and $Q=1$, $C=0.5$ for arrays of 3×10^4 defects. These Monte Carlo estimates are compared with the previously obtained bounds. It is also shown that at the special frequencies of Matsuda and for $Q \geqslant Q_{crit}$, the limiting value of $\alpha_N(\omega.Q,c)$ is positive in the entire concentration range $0 < C < 1$. Explicit upper and lower bounds are obtained on $\alpha[\sin(\pi/4), 1, c]$.

11440. Ruff, A. W., Jr., Ives, L. K., **Stacking fault energy determinations in HCP silver-tin alloys,** *Acta Met.* **17,** 1045-1055 (Aug. 1969).

Key words: Dislocation; dislocation double ribbons; dislocation nodes; hcp alloys; silver-tin alloys; stacking fault energy.

Measurements of the intrinsic stacking fault energy as a function of tin solute concentration are reported through the range of the intermediate hexagonal ζ-phase. Four different alloy compositions in the range 12 to 17 atomic percent tin were studied. Extended dislocation nodes and dislocation double ribbons were observed and measured in order to determine the stacking fault energy. The stacking fault energy values obtained from measurements on these two configurations were in good agreement and indicated that the magnitude of the stacking fault energy increased linearly with solute concentration in the hcp phase. The results are compared with those of the cubic α-phase alloys. The dislocation configurations in the hexagonal alloys are briefly described.

11441. Rush, J. J., Melveger, A. J., Lippincott, E. R., **Laser-Raman spectra of PH_4I, PH_4Br, and PH_4Cl,** *J. Chem. Phys.* **51,** No. 7, 2947-2955 (Oct. 1, 1969).

> Key words: Barrier to rotation; crystal force field; crystal structure; lattice modes; phosphonium halides; Raman spectra; torsional frequency; vibration.

Laser-Raman spectra have been measured at 23 ℃ for PH_4I and PH_4Br and at ~5 °C for PH_4Cl. Peaks observed in the spectra of all the halides are assigned to "internal" PH_4^+ modes, $\upsilon_1(A_{1g})$, $\upsilon_2(A_{1g},B_{1g})$, $\upsilon_3(E_g)$ and $\upsilon_4(E_g)$ and to torsional $[L_2(E_g)]$ and translational $[T_1(A_{1g})]$ lattice modes. The torsional frequencies are 326, 343 and 363cm^{-1}, respectively, for PH_4I, PH_4Br, and PH_4Cl, while the translational mode is observed at 55.5, 75 and 112cm^{-1}, respectively. Barriers to rotation are calculated from the torsional frequencies on the simple but unrealistic assumption of a "4-fold" cosine type potential for the PH_4^+ ions. The barriers obtained are 6.7, 7.4 and 8.2 kcal/mol, respectively for PH_4I, PH_4Br and PH_4Cl. The spectral results and calculated barriers are compared in some detail with previous optical, NMR and neutron scattering results for both the phosphonium and ammonium halides. Suggested differences in force fields between the ammonium and phosphonium salts are discussed.

11442. Ruthberg, S., **Calibration to high precision in the medium vacuum range with stable environments and micromanometer,** *J. Vacuum Sci. Technol.* **6,** No. 3, 401-412 (May-June 1969).

> Key words: Calibration; capacitance-diaphragm gauge; medium vacuum range; micromanometer; stable pressure generation; vacuum measurements.

Ultra stable vacuum environments are utilized with a micrometer point contact manometer as reference standard for measurement and calibration with an uncertainty of 1.2×10^{-4} torr + 6 parts in 10^5 of the reading from least count to several torr. The stable pressures are generated by dynamic vacuum systems and a servo control loop with cascaded error signals from a capacitance-diaphragm gauge for stabilities of better than 1 part in 10^5 at 1 torr. Precise evaluation of systems and procedures is given. Operational factors affecting accuracy were studied, such as sorption in the manometer fluid, pressure distribution in the test chamber, time constants in the micromanometer, and thermal response of the control loop.

11443. Ryan, J. V., **Federal Government's role and activities in consumer safety. The role of the Fabric Flammability Section,** *Proc. Spring Workshop, Home Conf.*, 5 pages, National Safety Council, General Session, Washington, D.C., (May 26, 1969).

> Key words: Fabrics; flammability; Flammable Fabrics Act; rugs; textiles; wearing apparel.

A review is given of consumer safety programs at the National Bureau of Standards, particularly those in response to legislation. The provisions of the Flammable Fabrics Act are listed and the chief items of implementation are discussed. Procedures for the development of standards have been published in the Federal Register. The initial step under the Procedures, a notice of finding that there may be need for new or amended flammability standards, has been taken for wearing apparel, carpets and rugs. Test method development in support of these findings is in progress. Research has been initiated in the flammability of materials. The National Advisory Committee for the Flammable Fabrics Act has been appointed and has met.

11444. Rybicki, G. B., Hummer, D. G., **Noncoherent scattering—V. Thermalization distances and their distribution function,** *Monthly Notices Roy. Astron. Soc.* **144,** 313-323 (1969).

> Key words: Noncoherent scattering; radiative transfer; spectral line; thermalization length.

The distribution function for thermalization lengths is derived for an infinite atmosphere with a plane source. Precise definitions of the thermalization length are discussed from the point of view of representing the distribution by a single characteristic length; of these a definition in terms of the median of the distribution seems to be most useful. The distribution of longest flights is derived and shown to provide a good approximation to the distribution of thermalization lengths at large distances from the source. Extensive numerical illustrations are provided.

11445. Santone, L. C., **Application of systems analysis to urban problems,** *International City Management Association, The Municipal Yearbook*, pp. 225-232 (1969).

> Key words: Accounting models; city management; facility location; operations research; simulation techniques; systems analysis; urban problems.

At present, systems analysis is considered a potential tool to aid in the resolution of urban problems. It is possible for city management to utilize the systems approach and perform certain techniques with minimum outside assistance. Three techniques discussed in this paper are accounting models, simulation models, and facility location models. Through these operations, cities may develop a library of resources for application to future problems. Because of similarity of problems, it may be possible to develop prototype models which would be available to all cities. In essence, systems analysis offers urban areas a process whereby it is possible to expand, validate, and organize knowledge concerning a system so that given a problem within the system, the alternative solutions may be more realistically evaluated.

11446. Scheer, M. D., Fine, J., **The desorption kinetics of Cl^- and I^- on Mo and Ta as determined by the pulsed-beam method,** (Proc. Sixth Intern. Symp. Rarefied Gas Dynamics, Cambridge, Mass., July 22-26, 1968), Chapter in *The Measurement of Sticking Coefficients at High Temperatures Using the Isotopic Mixing Method* **II,** 1469-1477 (Academic Press Inc., New York, N.Y., 1969).

> Key words: Binding energies; Cl^-; desorption lifetimes; I^-; Mo; Ta.

The desorption lifetimes of K^+ and Cs^+ on Mo were determined as a function of temperature. These results are in agreement with previously reported lifetime measurements of these ions on polycrystalline W and Re and hence appear to be independent of the metal substrate. A simple electrostatic potential model can describe this alkali positive ion-metal surface interaction.

In addition, desorption lifetime measurements were also made for I^- on and Ta and Cl^- on Mo. These results are summarized. It is seen that the binding energy between the halogen negative ions and the surface is strongly dependent upon the metal substrate. Further, the energy of a simple electrostatic bond between the halogen negative ion and the metal surface is about half that which is actually observed. Consequently, unlike the case for the alkali positive ions, a covalent (M-X) or $(M\text{-}X)^-$ precursor is required to account for these large halogen negative ion desorption energies.

11447. Scheer, M. D., Fine, J., **The electron affinity of lithium,** *J. Chem. Phys.* **50,** No. 10, 4343-4347 (May 15, 1969).

> Key words: Electron affinity; lithium; mass spectrometry; positive and negative surface ionization.

The positive and negative surface ionization of a lithium atom beam on a thin, heated, molybdenum ribbon was studied using a specially designed mass spectrometer. At a constant incident beam flux, Li^+ yields were determined as a function of surface temperature in the 1400 to 2100 K range. Using 5.39 eV for the first lithium ionization potential (I), this data yielded an average positive ion work function ($\bar{\phi}_+$) of 4.38 eV with a standard deviation of 0.01 eV. The [Li$^+$/Li$^-$] ratio was then determined at beam intensities and surface temperatures made sufficiently large to give measurable Li$^-$ yields. From the above values for I, $\bar{\phi}_+$, T, and [Li$^+$/Li$^-$], it was found that A(Li) $= \bar{\phi}_- - 3.35$ eV with a standard deviation of 0.05 eV. The quantity $\bar{\phi}_-$ is an average negative ion work function. This could not be measured with any precision because of the very small Li$^-$ yields. A recent determination of the single plane work functions of molybdenum shows a variation from 4.0 eV for the (116) plane to 5.0 eV for a (110) surface. Since the negative ion work function average accentuates the low work function patches, the maximum uncertainty in $\bar{\phi}_-$ is given by $4.0 < \bar{\phi}_- < 4.4$ eV. Consequently, the electron affinity of lithium is bounded by the following values: $0.65 <$ A(Li) < 1.05 eV. From previously reported measurements of the polycrystalline work function of molybdenum, it is concluded that A(Li) is more likely to be near the upper rather than the lower limit of this range of uncertainty.

11448. Schwartz, R. B., Schrack, R. A., Heaton, H. T., **A search for structure in the n-p scattering cross section,** *Physics Letters* **30B,** No. 1, 36-38 (Sept. 1, 1969).

Key words: Cross section; hydrogen; neutron; neutron-proton scattering; structure; time-of-flight.

The n-p total cross section has been measured in the energy range 1.5 to 15 MeV with good energy resolution and high statistical precision. No evidence of structure was found.

11449. Seidel, G. P., **Neutron radiation hardening of polycrystalline iron,** *Radiation Effects* **1,** 177-190 (1969).

Key words: Annealing; impurities; iron; radiation hardening; strain ageing; yield stress.

The dependence of the yield stress of vacuum-annealed and hydrogen purified iron polycrystals as a function of neutron dose and annealing temperature and the influence of these parameters on the effect of static strain-ageing has been investigated. The radiation hardening was found to depend sensitively on the interstitial impurities N and C. This is explained by both a nucleation of precipitation and a trapping of the impurities at radiation produced intrinsic defects. The radiation enhanced precipitation predominates in impurer iron and at low doses can be abolished through annealing below 190 °C. The trapping becomes effective at higher doses or in purer iron. Below 400 °C two recovery stages for the yield stress are observed (between 200 and 260 °C and between 320 and 400 °C), which can be explained by the detrapping of N and C respectively. The static strain-ageing was found to be reduced by neutron irradiation. It reappears after annealing at temperatures, at which the precipitates are thought to be redissolved and the C and N atoms to be detrapped.

11450. Shirley, J. H., **Validity of the semiclassical approximation in maser theory,** *Phys. Rev.* **181,** No. 2, 600-609 (May 10, 1969).

Key words: Correlations; laser; maser; phase fluctuations; semiclassical.

A simple model of a maser or laser consisting of a single mode field coupled to N identical two-level atoms is considered. The semiclassical approximation is equivalent to neglecting the statistical correlations between the atoms and the field. The accuracy of this approximation is investigated by writing equations of motion for the correlations. To obtain a complete, self-consistent set of equations, it is necessary to include correlations of the field with itself (related to the coherence of the field) and correlations between different atoms. Relaxations and an energy source are introduced phenomenologically into the equations of motion. They are then solved for the case of steady state oscillation. It is found that the correlations are smaller than the terms kept in the semiclassical theory by the order of one over the number of photons present in the field, larger if thermal photons abound, but smaller if the field relaxation is dominant. Expressions are also found for the amplitude and phase fluctuations of the field. The latter yield a linewidth for the maser oscillator in agreement with earlier calculations, but obtained by a different method.

11451. Shumaker, J. B., Jr., Popenoe, C. H., **Arc measurement of some Ar II optical transition probabilities,** *J. Opt. Soc. Am.* **59,** No. 8, 980-985 (Aug. 1969).

Key words: Ar II; arc; argon; lifetimes; transition probabilities.

Wall-stabilized arc measurements employing the generalized Fowler-Milne diagnostic technique have been carried out in argon at atmospheric pressure. Transition probabilities are reported for all lines of the 4s-4p and 3d-4p Ar II arrays lying below 7200 Å.

11452. Simpson, J. A., **Electron impact spectrometry for gas phase chemical analysis,** *Mater. Res. Stand.* **9,** No. 8, 13-16 (Aug. 1969).

Key words: CO in air; electron impact spectrometer; gas analysis.

Electron impact spectrometry provides a new tool for gas phase chemical analysis. The data obtained is directly related to ultraviolet optical absorption but is easier to obtain and interpret. The instrument is briefly described and its performance demonstrated on CO in air at 15 ppm.

11453. Sitterly, C. M., **Forbidden transitions in atoms: catalogs and identifications,** *Mem. Soc. Roy. Sci. Liege* **V,** No. 16, 17-29 (1969).

Key words: Analyses of spectra, grades; atomic spectra, forbidden lines; celestial spectra, forbidden lines; corona, identifications; forbidden lines; nebular lines.

Forbidden lines identified in various celestial spectra are summarized in a general chart arranged by element and by the spectra of different stages of ionization for a given element.

The subject is reviewed by grading our present knowledge of atomic and ionic spectra in five general classes ranging from grades A to E. A chart of these grades is presented.

In view of the present advances in space technology, and future plans for observing stellar spectra in the vacuum ultraviolet, the needs of the astrophysicist are appraised.

Since forbidden lines can be identified in celestial spectra only as a result of laboratory analyses of spectra, the present programs on analyses are described. Progress in the preparation of tabular data needed to derive wavelengths of forbidden lines is outlined. Relevant bibliographical work being carried on as part of the "Atomic Energy Levels" Program at the National Bureau of Standards is reviewed.

11454. Sparks, L. L., Powell, R. L., Hall, W. J., **Progress on cryogenic thermocouples,** (Proc. 1968 Cryogenic Engineering Conf., Case Western Reserve Univ., Cleveland, Ohio, Aug. 19-21, 1968), Chapter in *Advances in Cryogenic Engineering* **14,** Paper H-4, 316-321 (Plenum Press Inc., New York, N.Y., 1969).

Key words: Cryogenics; gold alloy; thermocouples.

Experimental tests between 4 and 280 K have been completed on the following thermocouple materials: Chromel, copper, "normal" silver, platinum, *silver*-28 at. percent gold, constantan, Alumel, and *gold*-(0.02, 0.03, 0.07) at. percent Fe. Many thermocouple combinations can be made from the above materials; the four most important being Chromel vs constantan, copper vs constantan, Chromel vs Alumel, and Chromel vs gold-0.07 at. percent iron. Results on the last combination are of particular interest for measurements near liquid hydrogen temperatures and will be presented in some detail. The calibration cryostat is described briefly. Special methods of measurement and data analysis have been designed to study and minimize systematic errors. Simple illustrations of these measurement schemes are given.

11455. Stair, R., **Measurement of natural ultraviolet radiation; historical and general introduction,** (Proc. Conf. Fourth International Biometeorological Congress, Rutgers University, New Brunswick, N.J., 1966), Chapter in *The Biologic Effects of Ultraviolet Radiation,* Frederick Urbach, ed., pp. 377-390 (Pergamon Press Inc., New York, N.Y., August 1969).

Key words: Natural ultraviolet; radiometry; solar irradiance; spectroradiometry; ultraviolet.

The development of methods for the measurement of natural ultraviolet is interwoven with many fields of optics and electricity. Three hundred years ago Newton first observed that a crude glass prism would separate white light into colors or conversely combine colors. This was followed by the discoveries of ultraviolet and infrared by Ritter and Herschel. Then followed the work of Fraunhofer, Bunsen and Kirchhoff relating to the spectra. The discovery of the thermoelectric effect and its use in measurement by Nobili and Melloni opened the way for accurate measurements. Next came the discoveries in photography, photoelectricity, and great improvements in instrumentation which led the way for the measurements of solar radiation by Rowland, Langley, Fabry and Buisson, Pettit, Abbot, Nicolet, Allen, Mulders, Johnson, Coblentz, Stair and others.

11456. Stiehler, R. D., **History of measurement and the SI units,** *Mater. Res. Std.* **9,** No. 6, 14-18 (June 1969).

Key words: Ancient measures; history; measurement; SI units; units of measurement.

The evolution of the units of measurement from ancient Babylonia and Egypt to the present is briefly described. The so-called English units did not originate in England; they descended from antiquity. The confusion caused by the multiplicity of ancient units that were in use in Europe during the Renaissance was the stimulus that led to the development of the metric units. Similarly, the multiplicity of metric units for the same quantity that have arisen since 1800 led to the development of the rational and coherent International System of Units (SI) which were adopted in 1960 by the General Conference on Weights and Measures. The advantages and weaknesses of SI are discussed.

11457. Strobridge, T. R., **Refrigeration for superconducting and cryogenic systems,** (Proc. 1969 Particle Accelerator Conf., Washington, D.C., March 5-7, 1969), *IEEE Trans. Nuclear Sci.* **NS-16,** Part 1, No. 3, 1104-1108 (June 1969).

Key words: Cost; cryogenic; efficiency; mass; refrigeration; volume; 1.8 to 90 K.

Cryogenics and high energy physics have been intimately associated for many years. The liquid hydrogen bubble chamber remains a primary detector for particle interactions and the recent successful development of superconducting RF cavities will vastly improve the duty cycle of linear accelerators. Aside from target and detection devices, it is not clear what role low temperature environments will play in the particle accelerators now being conceived. The amount of cooling required and the refrigeration temperatures may vary widely from concept to concept. To assist in planning, this survey of modern cryogenic refrigerators, covering refrigeration temperatures from about 1.8 to 90 K, gathers together performance, physical characteristic and typical cost information from industry, academic, and government sources both in the U.S. and abroad. Whenever possible, data on liquefiers are converted to an equivalent refrigeration capacity. The capacities discussed range from about one watt to kilowatts.

11458. Sukle, D. J., Wells, J. S., **Fine structure in EPR of Mn^{2+} in zinc sulfate,** *Phys. Rev.* **180,** No. 2, 445-450 (Apr. 10, 1969).

Key words: Anhydrous zinc sulfate; electron paramagnetic resonance; manganese ion.

The electron spin resonance of 0.01 percent Mn^{2+} in single crystals of $ZnSO_4$ has been studied in order to investigate the crystal field interaction, which may be representative of the single ion anisotropy in $MnSO_4$. The symmetry group for the zinc site, which the Mn^{2+} ions are assumed to occupy, is C_i. There are in general, four inequivalent zinc sites, which produce a spectrum of 320 possible lines at an arbitrary orientation. However, data have been taken with H_o in symmetry planes of the crystal so that pairs of inequivalent sites become equivalent. This results in some simplification of the spectrum and provides a method for accurate alinement of the crystal.

The spectrum has been fitted to a low symmetry spin Hamiltonian. Since crystal field terms are large, perturbation theory could not be used, and the spin Hamiltonian analysis of the spectrum was accomplished by computer programs which diagonalize the spin Hamiltonian parameters $C_{20} = 3.792 \pm 0.001 \times 10^{-2} cm^{-1}$, $C_{21} = 3.815 \pm 0.001 \times 10^{-2} cm^{-1}$, $C_{22} = 5.808 \pm 0.001 \times 10^{-2} cm^{-1}$ with lobe orientations $\lambda_{21} = 152.6^o$ and $\lambda_{22} = 86.5^o$ describe the room temperature spectrum reasonable well. The inclusion of the C_{4q} terms improves the fit.

11459. Swartzendruber, L. J., Bennett, L. H., Watson, R. E., **Dilute ^{5}Fe Mössbauer studies in Cu-Ni alloys,** *J. Appl. Phys.* **40,** No. 3, 1489-1490 (Mar. 1, 1969).

Key words: Copper; invar effect; iron; magnetism; Mössbauer; nickel.

The ^{57}Fe Mössbauer effect has been used to study the properties of iron as a dilute impurity in Cu-Ni alloys. Using either 0.5 at. percent Fe as an absorber or ^{57}Co as a source in Cu-Ni alloys, we find a small, partially resolved magnetic hyperfine field in what are normally considered nonmagnetic alloys. Previously the hyperfine field at 4 K was reported as undergoing a rapid decrease in value near the equiatomic composition: from 243 dT (243 kG) at 55 at. percent Ni to 0 dT (0 kG) at 45 at. percent Ni (both alloys are ferromagnetic at 4 K). The present work extends this study and finds that the magnetic field drops instead to the small value of 10 dT (10 kG). This field is almost independent of Ni concentrations between 10 and 45 percent Ni (i.e. in both ferromagnetic and paramagnetic regions). It is temperature independent between 4.2 and 298 K, and is the same for either the source or absorber (0.5%). The Mössbauer results suggest an invar-type effect occurs in this alloy system.

11460. Taggart, H. E., **Field strength and RFI standards at the National Bureau of Standards,** *Proc. IEEE Electromagnetic Compatibility Conf., Seattle, Washington, July 23-25, 1968,* pp. 149-158 (1968).

Key words: Antenna electromagnetic interference standards; calibration; measurement techniques.

Some of the calibration services offered to industry and other governmental agencies by the National Bureau of Standard's Radio Standards Laboratory are discussed. The emphasis is placed on field strength measurements and related calibration services at frequencies from 30 Hz to 12 GHz. These include the calibration of 3 basic types of antennas: (1) Loop antennas, (2) Half-wave dipole antennas and (3) Horn antennas. Methods of calibrating these antennas are described and illustrated.

A discussion of calibration problems at microwave frequencies emphasizing the measurements errors as related to the antenna and receiver voltage standing wave ratios (VSWR). Antenna and receiver VSWR's are exemplified, and corresponding measurement errors are shown. Methods of estimating errors are given.

The National Bureau of Standards recently designed and constructed some antenna standards for both the Air Force and the Navy. These standards were designed to calibrate loop and half-wave dipole antennas. The frequency range is 10 kHz to 1000 MHz. These antenna standards are briefly described and illustrated. The future plans for the development of antenna standards and broadband EMC standards at the National Bureau of Standards are discussed. Work is in progress in areas of impulse generators, random noise generators, and other instruments.

11461. Tate, E. L., **Variations on a theme: government and library cooperation,** *D.C. Libraries* **39,** No. 3, 53-55 (1968).

Key words: Library cooperation.

Increasing and changing demands for service are necessitating new cooperative programs among libraries in the Washington metropolitan area. These new programs, exemplified by the work of the Library Technical Committee of the Metropolitan Washington Council of Governments or the Federal Library Committee involve interagency rather than just interlibrary cooperation. Imaginative projects, like the High John project, have been the result.

11462. Thompson, B. A., LaFleur, P. D., **Activation analysis for molybdenum in samples containing large amounts of tungsten,** *Anal. Chem.* **41,** No. 13. 1888-1889 (Nov. 1969).

Key words: Activation analysis; molybdenum; radiochemistry; solvent extraction; technetium; tungsten.

Molybdenum has been determined by neutron activation analysis in the presence of large amounts of tungsten using a double extraction with bis (2-ethylhexyl) orthophosphoric acid (HDEHP). In the first extraction W and Mo are separated from the matrix elements. In the second extraction, made after equilibration of ^{99m}Tc with ^{99}Mo, the ^{99m}Tc daughter of ^{99}Mo is separated from W and Mo and used as a measure of the Mo present. The method is very rapid and has good precision and accuracy.

11463. Tipson, R. S., Brady, R. F., Jr., **Synthesis of the two D-2-pentuloses. New derivatives of D-*erythro*-pentulose,** *Carbohydrate Res.* **10,** 549-563 (Aug. 1969).

Key words: Acetonation; D-*erythro*-pentulose; D-*threo*-pentulose; isomerization; partition; pyridine.

The syrupy mixture of eight pentoses obtained by boiling a solution of either D-xylose (**1**) or D-arabinose (**2**) in pyridine for 4.5 hours was freed of the four D-aldopentoses. The resulting mixture of four D-pentuloses was resolved by condensation with acetone, followed by partition between solvents or by distillation. In this way, crystalline 2,3-*0*-isopropylidene-*β*-D-*threo*-pentulofuranose was readily prepared from **1**, and crystalline 1,2:3,4-di-*O*-isopropylidene-D-*erythro*-pentulofuranose (**14**) from **2**. Each of these isomerizations yielded a small proportion of the epimeric D-2-pentulose, but the proportions of the D-3-pentuloses were much lower. The diacetal **14** was partially hydrolyzed, with dilute acid, to 3,4-*0*-isopropylidene-D-*erythro*-pentulofuranose (**17**), the α-D-anomer of which was obtained in crystalline form. The structure of **17** was proved by oxidation with periodate, to give the known, crystalline 2,3-*0*-isopropylidene-D-erythrono-1,4-lactone. The anomers of the 1,3,4-triacetate and 1,3,4-tribenzoate of methyl D-*erythro*-pentulofuranoside were prepared, and characterized by specific optical rotation and n.m.r. spectroscopic evidence.

11464. Toots, J., Marton, L., **Optical properties of antimony and bismuth in the far ultraviolet,** *J. Opt. Soc. Am.* **59,** No. 10, 1305-1308 (Oct. 1969).

Key words: Antimony; bismuth; collective oscillations; dielectric constant electron-energy-losses; free-electron gas optical properties; plasma resonance; reflectance.

We have measured the multi-angle reflectance of Sb and Bi films in the region of collective oscillation resonance, for photon energies between 10 and 26 eV. Reflectances have been used to calculate the optical constants n and k, which in turn yield ϵ_1 and ϵ_2 as well as the real and imaginary parts of ϵ^{-1}. F or Sb the ϵ^{-1} function can be closely fitted with the inverted Drude-Sellmeier resonance formula. The center of the resonance is at 16.0 eV, with a half-width of 5.2 eV corresponding to a decay time of 1.2 $\times$ 10^{-16} s. The Bi data can not be fitted with a simple Drude-Sellmeier model, but it is in good qualitative agreement with the known electron energy absorption properties.

11465. Venable, W. H., Jr., Shumaker, J. B., Jr., **Observations of departures from equilibrium in a nitrogen arc,** *J. Quant. Spectr. Radiative Transfer* **9,** 1215-1226 (Sept. 1969).

Key words: Arc; nitrogen; nonequilibrium; spectral-intensity.

Atmospheric-pressure wall-stabilized arcs in nitrogen are found to exhibit molecular band intensities which are incompatible with the assumption of local thermodynamic equilibrium. Mechanisms to account for the departure from equilibrium are suggested.

11466. Verdier, P. H., **A simulation model for the study of the motion of random-coil polymer chains,** *J. Computational Phys.* **4,** No. 2, 204-210 (1969).

Key words: Chain dynamics; lattice model; Monte Carlo; polymer; simulation.

A lattice model of the dynamical behavior of a random-coil polymer chain in solution is described. Simulation of the model by a high-speed digital computer is discussed. The model appears especially suitable for the study of the effects of excluded volume interactions upon the motions of random-coil polymer chains.

11467. Viezbicke, P. P., **Interactions between nested receiving rhombic antennas,** *IEEE Trans. Ant. Prop.* **AP-17,** No. 1, 16-23 (Jan. 1969).

Key words: Antenna; comparison; co-planar; gain; interactions; mutuals; nested; patterns; planar; proximity; rhombic; spacing.

In order to install as many radiating circuits as possible in a given area, consideration has to be given to the operation of antennas in close proximity to one another. Therefore, mutual coupling between two nested rhombics and the effect of one rhombic on the radiation pattern of the other were measured.

For a ratio of antenna sizes of 2 to 1, the presence of either a coplanar or noncoplanar antenna had no influence on the gain and radiation pattern of the reference rhombic. To determine the minimum acceptable separation, measurements were extended to include rhombics almost equal in size and as close as practicable to each other. For wire separations of 0.5λ, the gain of the reference rhombic was reduced by 0.5 db. For 0.2λ separation the gain was reduced by 1 db, and for 0.04λ, by approximately 4 db. Except for very close spacings, the radiation patterns remained substantially unchanged.

Mutual coupling, expressed as transmission loss between the antennas in db, varied between −23 and −41 db.

11468. Viezbicke, P. P., **Why WWV moved to Colorado,** *Mark 5,* **13,** No. 3, 14-16 (June 1968).

Key words: High frequency broadcasts; standard frequencies; time signals; WWV.

This article outlines the reasons why WWV was moved from Greenbelt, Maryland to Fort Collins, Colorado. It summarizes the benefits resulting to the public.

11469. Waclawski, B. J., Hughey, L. R., **Effect of heating on the photoelectron yield of polycrystalline tungsten in the vacuum ultraviolet,** *J. Opt. Soc. Am.* **59,** 1494 (Nov. 1969).

Key words: Heating effects; photoelectron yield; spectral response; tungsten; ultra-high vacuum; vacuum ultraviolet.

The effect of heating on the spectral response of a previously atmosphere-exposed, polycrystalline tungsten photocathode was investigated for photon energies of 7.7, 10.2, 11.8, 16.9, and 21.2 eV. Use of ultra-high vacua $< 2 \times 10^{-9}$ torr precluded significant contamination of the sample after heating. The vacuum system bakeout at 630 K, as well as flashing the sample to 2200 K produced appreciable changes in the photoelectron yield (electrons per incident photon). The spectral response was modified by heating such that, compared to atmosphere-exposed tungsten, the yield decreased for photon energies greater than about 8 eV, but increased for lower photon energies.

11470. Waddell, W. J., Bates, R. G., **Intracellular pH,** *Physiol. Rev.* **49,** No. 2, 289-329 (1969).

Key words: Acidity; cell acidity; extracellular pH; glass electrode; intracellular pH.

Intracellular and extracellular pH are defined and methods for their determination are outlined. The literature on pH measurements in cells of the human body is summarized.

11471. Wagman, D. D., **Elements of chemical thermodynamics: introduction to thermal methods,** Chapter 86 in *Treatise on Analytical Chemistry,* Part **I,** *Theory and Practice,* I. M. Kolthoff, P. J. Elving, and E. B. Sandell, eds., **8,** 4909-4936 (Interscience Publ. Inc., New York, N.Y., 1968).

Key words: Equilibria; freezing point equation; ideal solution laws; thermal analyses; thermodynamic laws.

The chapter presents a short introductory statement of the principles of chemical thermodynamics, with special relevance to the laws used in the application of temperature and heat measurement to determinations of purity and extent of chemical reaction.

11472. Watson, R. E., Bennett, L. H., Freeman, A. J., **Comments on "origin of solvent Knight shifts in alloys,"** *Phys. Rev.* **179,** 590-592 (Mar. 10, 1969).

Key words: Alloys; charge impurity screening; hyperfine fields; Knight shift; noble metals; orthogonalized plane waves.

Objections, based on considerations of changes in electronic specific heat, to our proposal on the source of the changes in solvent Knight shift upon alloying, are examined and rejected.

11473. Weir, C. E., Piermarini, G. J., Block, S., **Instrumentation for single crystal x-ray diffraction at high pressures,** *Rev. Sci. Instr.* **40,** No. 9, 1133-1136 (Sept. 1969).

Key words: High pressure; single crystal; x-ray diffraction.

A diamond-anvil high pressure cell made of beryllium, a special goniometer head and a Buerger-type camera designed for x-ray diffraction by single crystals at high pressures are described in some detail. The most important problems still to be solved are discussed.

11474. Weir, C. E., Piermarini, G. J., Block, S., **Single crystal x-ray diffraction at high pressure,** *Proc. American Crystallographic Association/High Pressure X-ray Diffraction Symposium, Seattle, Washington, Mar. 23-29, 1969,* **5,** 105-111 (1969).

Key words: High pressure; single crystal; x-ray diffraction.

Apparatus and techniques used for single crystal x-ray diffraction at high pressures are described briefly. The three types of determinations carried out successfully are discussed. These are: (1) compressibility measurements; (2) unit cell and space group determinations on high pressure phases; and (3) a structure determination.

11475. Weisman, I. D., Bennett, L. H., **Quadrupolar echoes in solids,** *Phys. Rev.* **181,** No. 3, 1341-1350 (May 15, 1969).

Key words: KI; NiAl; nuclear magnetic resonance; pulsed nuclear resonance; quadrupolar interactions; spin echos.

In a classic paper, Solomon showed that the presence of inhomogeneous, first order quadrupolar interactions leads to the formation of extra "allowed" spin echoes in nuclei for which the spin $I = 5/2$. We demonstrate (both theoretically and experimentally) that shifting the rf phase of the second pulse by 90° (in a spin 5/2 system) enhances the allowed echoes by a factor of almost 5 in amplitude over the unshifted case. Using the density matrix formulation (and assuming no magnetic inhomogeneities), we have derived, for a 90° phase shift, the amplitude and shape dependence on the second pulse turning angle of the $3\tau/2$, 2τ and 3τ echoes. Experimental echo amplitudes and shapes (for both 0 and 90° phase shifts) were obtained, at room temperature, on ^{127}I in a fused sample of KI and these show quite good agreement with the calculations. Due to the enhancement, this technique affords a much easier separation of the respective distributions arising from the $3/2 \leftrightarrow 5/2$ and from the $1/2 \leftrightarrow 3/2$ satellite transitions than is possible in the unshifted case. Another feature of the phase shifted case is that, in favorable circumstances, the 3τ echo may be observed although the 2τ echo is obscured by the receiver recovery time. Preliminary data on quadrupole distributions at Al sites in NiAl intermetallic compounds are presented.

11476. Weiss, B-Z., Meyerson, M. R., **Effect of chromium diffusion coatings on fatigue in iron,** *Trans. Met. Soc. AIME* **245,** 1633-1643 (July 1969).

Key words: Armco iron; chromium diffusion coatings; crack formation; crack propagation; fatigue.

Chromium diffusion coatings on commercial Armco Iron lead to structural, compositional, and stress distributional changes in the outer layers. These changes affect the mechanism of fatigue crack formation. In chromized samples, the crack initiates below the Cr-rich zone after only a limited portion of the total lifetime (5 to 10%). The crack formation was observed at the grain boundaries, where precipitated Cr-carbides were found. Residual tensile stresses and a stress concentration caused by the carbides are considered as accelerating factors. In uncoated samples, the cracks form at slip boundaries after 40 to 50 percent of total lifetime. The propagation process in coated samples is slower than in uncoated samples, as a result of the moderate rate of propagation until such time as the crack proceeds completely through the coating. At best, the Cr-diffusion causes little if any increase in fatigue life, and in certain cases a severe deterioration in fatigue life is observed.

11477. West, E. D., Ishihara S., **Experimental evaluation of heater lead error in calorimetry,** *Rev. Sci. Instr.* **40,** No. 10, 1356-1359 (Oct. 1969).

Key words: Calorimeter; energy measurement; errors in calorimetry.

Improper location of the potential leads for calorimeter heaters can cause an appreciable systematic error. Calculations to estimate limits on this error are usually based on greatly simplified heat flow problems. An easily understood experimental test not involving such simplifications provides a more convincing demonstration of a limit on the magnitude of the systematic error. Such a test is provided by measurements with the same or equivalent heater leads and heaters of very different resistances.

11478. Wiederhorn, S. M., **Fracture of sapphire,** *J. Am. Ceram. Soc.* **52,** No. 9, 485-491 (Sept. 21, 1969).

Key words: Cracks; crack propagation; double-cantilever-cleavage technique; fracture; fracture surface energy; sapphire.

The fracture of sapphire was studied using the double-cantilever-cleavage technique. Fracture surface energies of 7.3 and 6.0 J/m^2 were found for the $(10\bar{1}0)$ and $(\bar{1}012)$ planes respectively. Attempts to measure the fracture surface energy on the (0001) plane proved unsuccessful. The failure of sapphire to fracture along the basal plane was attributed to the fact that these planes lack charge neutrality. The possibility of fracture induced dislocation motion in sapphire at room temperature was investigated. No evidence for dislocation motion was found and it was estimated that dislocations do not move in sapphire at room temperature at stresses less than approximately 7×10^9 N/m^2 (10^6 psi). Fracture behavior on $(\bar{1}012)$ planes was found to be erratic, varying from boule to boule. The topology of surfaces formed by crack propagation along this plane is described, but no explanation for the erratic behavior or the observed fracture features is given.

11479. Wiese, W. L., Bridges, J. M., Kornblith, R. L., Kelleher, D. E., **Transition probabilities for prominent Ar I lines in the near infrared,** *J. Opt. Soc. Am.* **59,** No. 9, 1206-1212 (Sept. 1969).

Key words: Atomic; infrared lines; neutral argon; transition probabilities; wall-stabilized arc.

Relative transition probabilities of 81 infrared Ar I lines in the wavelength range from 9000-24000 Å have been measured with a wall-stabilized arc operating in argon at atmospheric pressure. The large majority of the lines from the 4p-5s and 4p-3d transition arrays has been observed and the measurements are consistent with the J-file sum rule. The data have been normalized to an absolute scale by utilizing other recent arc and lifetime values.

11480. Wilson, W. K., Hebert, R. L., **Evaluation of the stability of record papers,** *Tappi* **52,** No. 8, 1523-1529 (Aug. 1969).

Key words: Accelerated aging; aging; deterioration; laboratory aging; preservation; records; stability.

Information has been developed on the relative stabilities of papers made from a variety of pulps including groundwood, neutral sulfite semichemical, bleached chemical wood and rag. After laboratory aging at 90 °C and 50 percent relative humidity for various time periods, changes in reflectance, pH, folding endurance, tear, burst, and tensile properties were determined. Alkaline papers as a group were more resistant to laboratory aging than any of the others. The papers made from groundwood also showed good resistance to aging. Papers containing large precentages of neutral sulfite semichemical pulp covered a wide range of stability depending on the pH. The pH was an important factor in laboratory aging, but the correlation between pH and the rate of deterioration of physical properties was not high.

11481. Wolcott, N. M., Falge, R. L., Bennett, L. H., **Magnetic behavior of intermetallic compounds of beryllium,** *J. Appl. Phys.* **40,** No. 3, 1377-1378 (Mar. 1, 1969).

Key words: Beryllium; ferromagnetism; intermetallic compounds; magnetic moment; nuclear magnetic resonance; paramagnetism.

The corroboration by NMR of the ferromagnetism of $CrBe_{12}$ has prompted an NMR investigation of the magnetic properties of other beryllium intermetallic compounds. Magnetic moment measurements of these materials show complex magnetic behavior at 4.2 K. All samples show strong paramagnetic moments and many exhibit remanence. To provide more information on this magnetic behavior, the ^{9}Be resonance was observed in the following samples, listed in approximate order of their magnetic strength at 4.2 K: $CrBe_{12}$, $ZrBe_2$, $MnBe_8$, $FeBe_{11}$, $MnBe_{12}$, $NbBe_3$, $ZrBe_{13}$, $TaBe_3$, $CrBe_2$, Nb_2Be_{17}, $TiBe_{12}$, $NbBe_{12}$, VBe_{12}, $MoBe_{12}$, $TaBe_{12}$, WBe_2, Ta_2Be_{17}, WBe_{12}. Magnetization measurements are also reported for $AgBe_{12}$, $FeBe_{12}$, $CoBe_{12}$, $PtBe_{12}$, $PdBe_{12}$, and $AuBe_{12}$. Both the Knight shifts and the linewidths show correlation with the moment measurements. Most of the samples show small magnetic moments, positive Knight shifts, and small linewidths, ΔH, less than (800 A/m = 10 Oe). $ZrBe_2$ and $MnBe_8$ have larger moments, negative values of K (~ −0.03% at 300 K) and larger ΔH (~(12 kA/m = 15 Oe) at 300 K). $CrBe_{12}$, clearly ferromagnetic, with the largest moment (of the compounds studied) has the most negative value of K (−0.19% at 300 K) and the largest ΔH ((1.83 kA/m = 23 Oe) at 300 K). From the *temperature dependence* of the linewidths, it appears that $NbBe_3$ and $CrBe_2$ may be magnetic, although much weaker than $CrBe_{12}$. Anisotropic Knight shifts and first order quadrupole effects are noted.

11482. Woo, S. B., Branscomb, L. M., Beaty, E. C., **Sunlight photodetachment rate of ground state O_2^-,** *J. Geophys. Res. Space Physics* **74,** No. 11, 2933-2940 (June 1, 1969).

Key words: Drift tube; ion mobility; oxygen negative ion; O_2^-; photodetachment; photoionization.

Swarm, instead of the usual crossed-beam, technique is used to measure the sunlight photodetachment rate of O_2^-. The advantage of this technique is that the molecular negative ions can be relaxed through approximately 10^6 collisions at thermal energy to ground vibrational and electronic state, before being introduced to the photodetachment chamber. Consequently, one can be confident of the applicability of data to the mesophere where the molecular negative ions are thought to be in thermal equilibrium with the temperature of the neutral gas. The measured absolute sunlight photodetachment rate of O_2^- is 0.3 ± 0.1 per ion per second. This value is obtained through a relative measurement, calibrating against the 1.44 sec^{-1} absolute sunlight photodetachment value of O^-, reported by Branscomb. A preliminary absolute solar-spectrum photodetachment rate of O_3^- is reported. This value is 0.06 per ion per second, believed good to a factor of two.

11483. Yakowitz, H., Michaelis, R. E., Vieth, D. L., **Homogeneity characterization of NBS spectrometric standards. IV: Preparation and microprobe characterization of W-20% Mo alloy fabricated by powder metallurgical methods,** (Proc. 17th Annual Conf., Applications of X-ray Analysis, Estes Park, Colo., Aug. 21-23, 1968), Chapter in *Advances in X-ray Analysis*, C. S. Barett, G. R. Mallett, and J. B. Newkirk eds., **12,** 418-438 (Plenum Press Inc., New York, N.Y., 1969).

Key words: Homogeneity testing; metallography; microprobe analysis; NBS standards; powder metallurgy; tungsten-molybdenum alloys.

A significant problem of the National Bureau of Standards Standard Reference Materials program is the provision of standards suitable in homogeneity for use with microanalytical techniques such as the spark source mass spectrograph and the electron probe microanalyzer. An interim approach to the problem has been the extended homogeneity characterization of selected existing standards. This paper describes the preparation and evaluation of the first NBS standard tested specifically from the beginning for application to electron probe microanalyzers.

The standard designated SRM 480 is a tungsten-20 weight percent molybdenum alloy prepared by a powder metallurgy process. Based on the results of about 1500 determinations for both tungsten and molybdenum by electron probe microanalysis, the material was found to be of high homogeneity at about the micrometer level of spatial resolution. The coefficient of variation for molybdenum was 2.5 percent and that for tungsten 1.5 percent. Correction of relative intensity ratios to obtain concentrations is discussed in terms of input parameter uncertainties such as mass absorption coefficients, and electron backscatter factors. The result of studies for atomic number correction and effects on operating voltage on the microprobe absorption correction, will be given. It is concluded that SRM 480 should be a valuable addition to any microprobe laboratory doing quantitative analyses.

11484. Yates, J. T., Jr., Madey, T. E., **Chemisorption on rhenium: N_2 and CO,** *J. Chem. Phys.* **51,** No. 1, 334-337 (July 1, 1969).

> Key words: Carbon monoxide; chemisorption; isotopic mixing, flash desorption; molybdenum; nitrogen; rhenium; sticking coefficient; tungsten.

The chemisorption of N_2 and CO on polycrystalline Re has been studied using flash desorption. A number of binding states have been identified and their binding energies have been estimated kinetically. Isotopic mixing between chemisorbed species has been observed for the β-N_2 and β-CO states on Re; there appears to be no evidence for dissociation of β-CO. The γ-N_2 and two α-CO states on Re desorb without isotopic mixing.

In general, the distribution and properties of binding states for N_2 and CO on Re are remarkably similar to those found for these adsorbates on W.

An enhancement in nitrogen adsorption on Re occurs upon electron impact (150 eV) on N_2(g). A new set of strongly-bound states are produced which are distinct from the β-N_2 states populated by adsorption of ground state N_2(g).

A comparison of the sticking coefficients for N_2 and CO on Re is made, using two independent methods (uptake and isotopic mixing) over a wide temperature range. The sticking coefficient for N_2 on Re decreases markedly with increasing temperature; for CO on Re, there is little effect of temperature on the sticking coefficient.

A discussion is presented of migration-limited bimolecular kinetics at elevated temperatures in the chemisorbed layer.

11485. Yates, J. T., Jr., Madey, T. E., **Electron impact study of the γ-N_2 state chemisorbed on tungsten,** (Proc. Fourth International Materials Symp., Berkeley, California, June 1968), Chapter in *The Structure and Chemistry of Solid Surfaces,* Gabor A. Somorjai, ed., pp. 59-1, 59-27, (John Wiley and Sons, Inc., New York, N.Y., 1969).

> Key words: Binding states; chemisorption; electron impact; flash desorption; nitrogen; tungsten.

Low energy (<75 eV) electron-impact conversion of the weakly-chemisorbed molecular γ-N_2 species on tungsten to more strongly bound chemisorbed species has been observed. It is possible to more than double the surface concentration of strongly bound nitrogen by this means. Neither N_2^+ nor N^+ were detected upon electron bombardment of γ-N_2 ($Q^+ < 1.4 \times 10^{-23}$cm^2). For 45 eV electron impact, the cross section for the depletion of the γ-N_2 state is $\sim 1 \times 10^{-19}$cm^2. Isotopic mixing between $^{14}N_2$ and $^{15}N_2$ does not occur in the γ-N_2 state upon electron impact.

11486. Young, D. S., Mears, T. W., **Measurement and standard reference materials in clinical chemistry,** *Clin. Chem.* **14,** No. 10, 929-943 (Oct. 1968).

> Key words: Clinical; measurement; medicine; Standard Reference Materials.

The concept of the measurement system based upon the four parameters—length (meter), mass (kilogram), time (second), and temperature (Kelvin)—is developed. The proper daily operation of an analytical laboratory depends on these basic measurements, and several derived from them, e.g., the liter. An additional component of chemical measurement which directly influences accuracy is the purity of the standards and reagents employed. The Standard Reference Materials program of the National Bureau of Standards provides a central source of guaranteed high-purity reference materials which are available to all. The reliability of chemical measurements will increase as new Standard Reference Materials such as cholesterol, uric acid, urea, and creatinine are utilized to standardize methods and instruments in the clinical laboratories of this country.

11487. Beatty, R. W., ed., **Commission 1, Progress in radio measurement methods and standards (Triennial report of progress),** *Radio Sci.* **4,** No. 7, 579-590 (July 1969).

> Key words: International Scientific Radio Union Report; measurement methods; radio measurements; radio standards; URSI XVIth General Assembly.

A review of progress within the USA in Radio Standards and Measurement Methods, covering the period 1966-1968, inclusive, is presented. This review is a part of the Triennial Report of the U.S. National Committee of URSI (International Scientific Radio Union) to the XVIth General Assembly of URSI.

The following topics dealing with U.S.A. progress in Radio Standards and Measurement Methods are included: Time and Frequency; CW Power; CW Voltage; Noise; Pulsed Voltage and Power; Attenuation, Phase Shift, and Time Delay; Impedance; Antenna Characteristics; Field Strength; RF Properties of Materials; Broadband Measurement Techniques; and Laser Measurements.

The report does not include all the developments which have occurred in the U.S.A. in the period indicated, but rather has attempted to include the most significant developments in each field.

11488. Bennett, H. S., **F center in ionic crystals. II. Polarizable-ion models,** *Phys. Rev.* **184,** No. 3, 918-935 (Aug. 15, 1969).

> Key words: F center; Huang-Rhys factor; ionic crystals (NaCl, KCl, MgO, CaO, SrO, CaF_2, SrF_2, BaF_2); polarizable ion; zero phonon transition.

The states of the *F* center are considered on the basis of models which treat the movement of the nearest neighbors to the *F* center and the *F* electron in a self-consistent manner. The lattice is first described in terms of a classical ionic-crystal theory. The theory is then extended to treat the nearest-neighbor ions in a quantum-mechanical manner. The one defect electron (the *F* electron) is treated according to polarizable-ion models. The absorption energy, the emission energy, the lifetime of the first excited state, the zero-phonon transition energies, and the Huang-Rhys factors are evaluated for two models, which differ in the rigor used to compute the polarization of the nearest and next-nearest neighbors. It is found that the model that contains the more rigorous evaluation of the polarization agrees best with the experimental results for CaO and perhaps MgO. In addition, it is found that both these models are least successful for *F* centers in NaCl and KCl. Not enough data exist to make judgments about the agreement for CaF_2, SrF_2, and BaF_2.

11489. Bennett, H. S., **Frequency shifts of acoustic phonons in Heisenberg paramagnets. III,** *Phys. Rev.* **185,** No. 2, 801-804 (1970).

Key words: Acoustic phonons; antiferromagnet; attenuation; EuO; ferromagnet; magnetic insulators; MnF_2; phonon frequency shift; RbMnF_3.

The propagation of sound waves in ferromagnetic and antiferromagnetic insulators is studied within the framework of two models which describe the interaction between the spin system and the lattice. Expressions for the frequency shifts (phonon renormalizations) at high temperatures and near the transition temperatures are obtained in terms of time-dependent correlation functions. The frequency shifts for long-wavelength phonons are found to be negative, to increase rapidly in the vicinity of the transition temperature, and to be less singular than the attenuation coefficients. The ratio of the frequency shift to the unperturbed phonon frequency is shown to be independent of the phonon frequency for long wavelengths. These results agree qualitatively with present experiments.

11490. Bennett, L. H., Swartzendruber, L. J., Watson, R. E., **Magnetic clusters associated with isolated Fe atoms in paramagnetic Cu-Ni alloys,** *Phys. Rev. Letters* **23,** No. 20, 1171-1174 (Nov. 17, 1969).

Key words: Alloys; Cu; Fe; magnetism; moments; Mössbauer effect; Ni.

A small magnetic cluster is shown to exist around an isolated Fe atom in $\mathrm{Cu}_{1-x}\mathrm{Ni}_x$ alloys with a magnetic moment and saturation hyperfine field depending on the number n of Ni near neighbors. This small cluster changes abruptly from moments of $(2.85 + 0.6n) / \mu_B$ to large moments $[(\sim 17 \text{ to } 20)\mu_B]$ for Ni concentrations near the critical composition. The moment compensation (Kondo effect) found for isolated Fe in Cu appears to persist in Cu-Ni up to at least 10 at. percent Ni.

11491. Berger, M. J., Seltzer, S. M., **Calculation of energy and charge deposition and of the electron flux in a water medium bombarded with 20-MeV electrons,** (Proc. Conf. High Energy Radiation Therapy Dosimetry under the auspices of the American Association of Physicists in Medicine, New York, N.Y., June 15-17, 1967), *Ann. N.Y. Acad. Sci.* **161,** Art. 1, 8-23 (July 3, 1969).

Key words: Charge deposition; electrons; energy deposition; flux; Monte Carlo; multiple scattering.

A combination of Monte Carlo and analytical techniques is used to compute the penetration of fast electrons in water, taking into account multiple elastic scattering by atoms, multiple inelastic scattering by atomic electrons, and the production of bremsstrahlung. Secondary electrons are also considered which result from electron-electron collisions, or from the absorption or scattering of bremsstrahlung. The calculation provides information about the spatial distribution of energy deposition, charge deposition and the electron flux (primary and secondary) down to a spectral energy of 400 eV. Representative results are presented, mainly for 20-MeV electrons incident prependicularly on a semi-infinite water medium.

11492. Blandford, J. M., **In-plant testing for wash-and-wear apparel performance and labeling,** *Third Annual Tech. Conf. The Apparel Research Foundation, Inc., Washington, D.C., Oct. 14-16, 1969,* 12 pages (Oct. 14, 1969).

Key words: Apparel; care instructions; labeling, apparel; performance, apparel; properties, apparel; testing textiles; wash-and-wear.

A distinction is made between washable garments, in general, and wash-and-wear apparel, in particular, with reference to the properties associated with appearance, performance, and ease of care. The testing equipment, testing procedures, and evaluation materials required by the apparel manufacturer in his assessment of these properties and formulation of ease-of-care instructions for labels and hang tags, are discussed. Tabulations and charts are included.

11493. Braun, W., Carrington, T., **Line emission sources for concentration measurements and photochemistry,** *J. Quant. Spectr. Radiative Transfer* **9,** 1133-1143 (1969).

Key words: Absorption; analysis; gas; photochemistry; spectroscopy; vacuum ultraviolet.

When a resonance line is absorbed in its own gas, measurements of this absorption can be used to derive a value of the product, nf, of concentration of the absorber and f-value of the transition. This line absorption process is also important in the study of fluorescence and photochemistry, where it is possible to produce atoms or molecules in a single quantum state without otherwise disturbing the system. The interpretation and success of these applications of line absorption depend critically on the shape of the line emitted by the light source. This is strongly influenced by the optical depth in the emitting region, and by the inevitable presence of a reversing layer through which the light must travel on its way out of the lamp. This paper presents a simple model which can be used to estimate the effects of these properties of the light source on the threshold and sensitivity of measurements of nf, and on the power which can be delivered to absorbing atoms outside the lamp. Emphasis is on the general principles of lamp design and diagnosis, rather than on accurate description of a particular lamp.

11494. Brenner, F. C., **Research for a uniform quality grading system for tires,** *Rubber Chem. Technol.* **42,** No. 5, 1446-1449 (Dec. 1969).

Key words: Bias ply; grading; passenger car tires; radial tires; speed capability; tires; winter tires.

The National Traffic and Motor Vehicle Safety Act of 1966 requires the establishment of a *uniform quality grading system.* This paper discusses the needs for the system and the complexity of the problem. The system proposed here will depend on five properties; tread wear, traction, impact resistance, endurance, and wheel speed capability.

11495. Brenner, F. C., Barton, F. W., **Cuts and cut growth in tires,** *Rubber Chem. Technol.* **42,** No. 5, 1462-1465 (Dec. 1969).

Key words: Cut growth; cutting; road test; tires.

Forty tires were subjected to severe road use on a course (approximately 3500 miles) that included Belgian block, over highways at turnpike speeds while overloaded. The course was repeated until the tires were worn smooth. At the end of each course, the number of new cuts and the length of all cuts in grooves was determined. Ten miles of Caliche (sharp stones) road was included between the first and second measuring period.

The tires experienced a total of 169 cuts. Forty seven (47) of these grew, 34 of which grew less than 0.11 inch. No cut grew continuously throughout the test. The cuts grew but not enough to cause tire failure except in one case where the cut exposed the fabric.

11496. Brenner, F. C., Mandel, J., Simson, B. G., **Research for a uniform quality grading system for tires. II. Wheel speed capability test,** *Rubber Chem. Technol.* **42,** No. 5, 1450-1461 (Dec. 1969).

Key words: Bias ply; grading; passenger car tires; radial tires; speed capability; tires; winter tires.

The wheel speed capability of a tire is defined by a test method which determines the speed at which the tire fails on a laboratory test wheel. Data is reported on over 100 different passenger car tires of all grades and types over a range of sizes.

A scaling system is devised for this property. It is found that the system produces consistent results for tires of given manufacturer's nominal grade across the size range tested and for samples produced several months apart.

11497. Deslattes, R. D., **Optical and x-ray interferometry of a silicon lattice spacing,** *Appl. Phys. Letters* **15,** No. 11, 386-388 (Dec. 1969).

Key words: Interferometer; lattice parameter; x-ray.

A device permitting simultaneous x-ray and optical interferometry over traverses in excess of 20 μm is reported. Results obtained to date suggest that such devices will permit measurements of certain crystal-lattice spacings with accuracies better than one part per million.

11498. Deslattes, R. D., **Relative energy measurements in the *K* series of argon,** *Phys. Rev.* **186,** No. 1, 1-4 (Oct. 5, 1969).

Key words: Argon; energy relation; x-ray spectra.

The relative positions of the principal features of the emission and absorption spectra of argon in its K series have been measured. The energy difference between the K-series Rydberg limit and the peak of $K\beta_{1,3}$ is compared with the optical ionization potential. Location of the K-series limit via the experimental ionization potential leads to new values for the L_{II} and L_{III} terms from measurements of $K\alpha_2$ and $K\alpha_1$. These are in reasonable agreement with Hartree-Fock calculations, and with recent grating measurements from other laboratories and single-crystal measurements newly reported here.

11499. Ernst, M. H., Dorfman, J. R., Hoegy, W. R., Van Leeuwen, J. M. J., **Hard sphere dynamics and binary collision operators,** *Physica* **45,** 127-146 (1969).

Key words: Binary collision expansion; binary collision operator; hard sphere dynamics; N-body dynamics; overlap function W; overlapping configuration.

The dynamics of a classical hard sphere system has as peculiarties that the particles suffer instantaneous collisions and that certain ("overlapping") areas in phase space are not accessible to the particles. It is mainly the latter feature that prevents a straightforward application of the usual binary collision expansion, generating the particle trajectories. Depending on how the relevant streaming operators are extended to the overlapping area's binary collision expansions can be developed. The different expressions so far proposed are critically examined and the restrictions to their applicability are determined. The binary-collision expansion for potentials consisting of a hard core and a soft tail is also discussed.

11500. Farrar, T. C., Tsang, T., Johannesen, R. B., **Internal reorientations in K_2ReH_9 via wide-line and pulsed proton resonance studies,** *J. Chem. Phys.* **51,** No. 8, 3595-3596 (Oct. 15, 1969).

Key words: Internal reorientation; nuclear magnetic relaxation; potassium rhenium hydride; potential barrier; proton; second moment.

Proton spin-lattice relaxation times (T_1) and second moments (M_2) have been measured as a function of temperature for K_2ReH_9. The activation energies for internal reorientation of $ReH_9^=$ ions, and their rms errors, are 9.9 ± 0.4 and 25.0 ± 0.8 kJ/mole (2.4 ± 0.1 and 6.0 ± 0.2 kcal/mole), respectively, for type *a* and *d* sites. Our results suggest that the barriers are determined by nearest-neighbor $ReH_9^= - ReH_9^=$ interactions.

11501. Fatiadi, A. J., **Novel aromatization of a trihydroxycyclohexanetrione (triketoinositol) to a dibenzo-*p*-dioxin derivative,** *Carbohydrate Res.* **12,** 130-132 (1970).

Key words: Acetylation; aromatization; benzenehexol; carbonium ion; dibenzo-*p*-dioxin; hemiacetal; hydrogen shift.

Novel aromatization of a triketoinositol on acetylation in the presence of acidic catalyst is described. Treatment of 4,6/5-trihydroxy-1,2,3-cyclohexanetrione (a triketoinositol) with acetic anhydride and 100 percent phosphoric acid yields octaacetoxy dibenzo-*p*-dioxin in 38-42 percent yield. It is believed that reaction proceeds by isomerization on a half of triketoinositol to benzenehoxol followed by intramolecular cycloaddition with the formation of a bishemiacetal intermediate. Aromatization of a newly formed ring probably involves: (a) carbonium ion formation, (b) hydrogen shift, and (c) elimination of two molecules of water. The structure was proved by ultraviolet, infrared, nuclear magnetic resonance, and mass spectroscopy.

11502. Hoegy, W. R., **Convergent generalization of the Boltzmann equation for a hard-sphere Lorentz gas,** *Phys. Rev.* **185,** No. 1, 210-218 (Sept. 5, 1969).

Key words: Binary collision expansion; generalized collision integrals; multiple scattering system; physical expansion; single scatter propagator.

A generalization of the Boltzmann equation for a classical Lorentz gas with hard-core interaction is presented. The N-body streaming operator is evaluated directly from the dynamics, thereby avoiding the binary collision expansion. A cluster expansion is developed in a form that results in exponential decay of the dynamical correlations and regularizes all divergent diagrams. Virtual collisions, represented by virtual binary kernels, are related to configuration-space restrictions, which in turn are responsible for the collisional damping. A prescription is given for the convergent l-body collision integral.

11503. Hust, J. G., **A compilation and historical review of temperature scale differences,** *Cryogenics* **9,** No. 6, 443-455 (Dec. 1969).

Key words: Temperature; temperature scales; thermometry.

A brief review is given of temperature scales, their definition, and measurement. Methods of practical temperature measurement are described. Differences between internationally accepted temperature scales are presented graphically and in tabular form; comparisons are also given for several national temperature scales. Emphasis has been placed on temperatures below 0 °C, but some information on temperatures above 0 °C has also been included. Suggested methods of conversion between different temperature scales are described.

11504. Jones, M. C., **Far infrared absorption in liquid hydrogen,** *J. Chem. Phys.* **51,** No. 9, 3833-3834 (Nov. 1, 1969).

Key words: Absorption coefficient; absorption mechanisms; infrared; liquid hydrogen; orthohydrogen; parahydrogen; translational absorption.

The far-infrared spectra of liquid hydrogen at three para concentrations have been recorded in the wavenumber range 20 to 250 cm^{-1}. The observed variation of the absorption coefficient with composition is consistent with the theory of translational absorption of Poll and Van Kranendonk.

11505. Jones, M. C., Giarratano, P. J., Simpson, A. U., **Heat transfer to solid-vapor mixtures of cryogens below their triple points flowing through heated tubes,** *AIChE J.* **15,** No. 5, 890-897 (Nov. 1969).

Key words: Boundary layer; cryogenic; heat transfer; hydrogen; low pressure; nitrogen; particle-wall interaction; solid-vapor; tube; two-phase.

Data are presented for wall temperatures and heat transfer coefficients for solid-vapor mixtures of parahydrogen and nitrogen flowing in an electrically heated straight tube of length 40 times its diameter. These are interpreted by the application of flat plate, constant property boundary-layer theory to models in which the solid particle geometrical distribution takes on simple limiting forms. The observed enhancement of the heat transfer coefficient over that for gas alone traveling at the same velocity is qualitatively predicted as a function of a dimensionless heat flux, the Sterman parameter $q_w/\rho_c U\lambda$.

11506. Kamper, R. A., **The Josephson effect,** *IEEE Trans. Electron Devices* **ED-16,** No. 10, 840-844 (Oct. 1969).

Key words: Electron tunneling; electronics; low temperature; superconducting devices.

This is a review of the Josephson effect in superconductors, with emphasis on the electrical properties of Josephson junctions and their application to devices and measurement techniques.

11507. Ku, H. H., Varner, R. N., Kullback, S., **Analysis of multidimensional contingency tables,** (Proc. 14th Conf. Design of Experiments in Army Research Development and Testing, Edgewood Arsenal, Md., October 23, 1968), *ARO-D Report* **69-2,** 141-180, (U.S. Army Research Office-Durham, Durham, North Carolina, Sept. 1969).

Key words: Contingency tables; computer programs; estimation of cell frequencies from marginals; generalized independence; higher-order interaction; hypothesis testing; information theory; interaction.

This is an expository paper on the analysis of contingency tables given at the Fourteenth Conference on the Design of Experiments. The principle of minimum discrimination information estimation is described and used to generate estimates for tests of hypotheses concerning second-order and higher-order interactions. All classical hypotheses for contingency tables can be generated by the use of this principle when certain marginals are considered as fixed.

Examples are given and two available computation programs are described in detail.

11508. McClintock, M., Balling, L. C., **Atomic and molecular fluorescence from laser excited diatomic cesium and rubidium,** *J. Quant. Spectro. Radiative Transfer* **9,** 1209-1214 (1969).

Key words: Atomic fluorescence; cesium rubidium; laser induced fluorescence; molecular fluorescence.

It has been found that several argon laser lines and the 6328 Å helium-neon laser line cause excitation of diatomic rubidium and cesium in the vapor phase to excited electronic states. The excitation of only a few, well separated rotation levels in the upper state, and the resulting simple line fluorescence spectra will allow determination of molecular constants not available by other methods. Atomic fluorescence was also present. Twenty-seven atomic cesium lines were observed between 3611 and 8946 Å under illumination at 4880 Å. The intensities of several atomic lines were found to have a quadratic dependence upon laser intensity, and are therefore attributed to excitation processes involving two photons.

11509. McDonald, D. G., Kose, V. E., Evenson, K. M., Wells, J. S., Cupp, J. D., **Harmonic generation and submillimeter wave mixing with the Josephson effect,** *Appl. Phys. Letters* **15,** No. 4, 121-122 (Aug. 15, 1969).

Key words: Infrared; Josephson effect; lasers; submillimeter waves; superconductivity.

By observing constant-voltage steps from Josephson junctions at voltages as high as 17 mV we deduce that junctions can generate harmonics up to frequencies as high as 8200 GHz. In consonance with this, submillimeter wave laser detection, harmonic generation and mixing are demonstrated. These results suggest a model for the upper frequency limit of the Josephson effect.

11510. Margoshes, M., Rasberry, S. D., **Application of digital computers in spectrochemical analysis—computational methods in photographic microphotometry,** *Spectrochim. Acta* **24B,** 497-513 (1969).

Key words: Computers; emulsion; microphotometry; photographic emulsion; photographic photometry; photometry; programs; spectrochemical analysis.

A new method of computation is described for calibration of photographic emulsions and conversion of microphotometer readings to relative intensities on a digital computer with special application to spectrochemical analysis. The method for emulsion calibration replaces graphical procedures by a numerical method which is well suited for digital computations. The method of computation and its underlying assumptions are described, and results are given of tests of the procedure. It is recognized that the entire experimental arrangement is being calibrated, not merely the photographic emulsion, and it is shown how malfunctions of the microphotometer which affect the calibration can be recognized from the output of the computer. The program for conversion of microphotometer readings to relative intensities provides for several alternate calculations, including selection of the proper calibration parameters according to the wavelength of the line when these data are supplied for more than one wavelength region, as well as correction for step and background where required. The program is written to provide for automatic selection of the required alternative calculation, based on preliminary analysis of the input data.

11511. Meinke, W. W., **The NBS Standard Reference Materials Program: Past, present, and future,** *Mater. Res. Std.* **9,** No. 10, 15-18 (Oct. 1969).

Key words: Primary standards; standards; standard reference material.

The past 60 years have been ones of rapid and sweeping technological change in the industrial world. During this time the National Bureau of Standards (NBS), has played a pivotal role in the orderly progress and quality control of the nation's productive process. One of the means by which this progress has been aided is through the production, certification, and issuance of Standard Reference Materials (SRM's) from NBS.

The development of our high-technology society is based in large part on the mass production of goods and services. In turn, mass production implies strict quality control of the means of production, an ever-increasing accuracy of measurement, interchangeability of parts, and stringent performance criteria for the wide variety of materials now used. The base of this structure rests firmly on a well-established standards program, national in scope, in which the NBS-SRM program plays a significant role. It is interesting to note that the national standards bodies, the ASTM being among the foremost, have interacted from the earliest days with the NBS-SRM program.

11512. Mies, F. H., **Resonant scattering theory of association reactions and unimolecular decomposition. II. Comparison of the collision theory and the absolute rate theory,** *J. Chem. Phys.* **51,** No. 2, 798-807 (July 1969).

Key words: Absolute Rate Theory; association; configuration interaction; quantum mechanics; recombination decomposition; resonance scattering; scattering theory; unimolecular kinetics.

The rate expressions derived in the preceding paper using a resonant scattering theory (RST) to describe recombination and unimolecular decomposition are compared with the absolute rate theory (ART). A one-to-one correspondence exists between the resonance states in RST and the activated states in ART. The "states of the activated complex" are shown to be the channel states in RST, and using the adiabatic approximation to describe the continuum states it is shown that ART does give a proper *upper bound* to the rate even when nonadiabatic effects are included in RST, i.e., the mean transmission coefficient κ is equal to or less than one. The collision theory gives explicit expressions for $\kappa(kT,P)$ which is a function of temperature and includes the dependence on pressure. Specific expressions are given for the "tight complex," where the "activated complex" occurs at some distorted region in configuration space, and for the "loose complex," where the activated complex is the rotational barrier in the asymptotic channel states. Particular attention is given to the high-pressure rate constant where the specific transmission coefficient can be simply related to the ratio of the mean widths to the mean spacings of the activated states. Criteria are given for the validity of ART, and it is shown that Light's statistical theory of reaction rates is a special microcanonical version of the ART for the "loose complex."

11513. Mullen, L. O., **On efficient use of selective vacuum pumping modes,** *J. Environ. Sci.* **12,** No. 5, 26-30 (Oct. 1969).

Key words: Cryopumps; getters; ion pumps; pumping efficiency; sublimation pumps; vacuum pumps; vapor pressure.

Most vacuum pumps are selective in the sense that they pump different molecular species at different speeds. Some pumps, such as sublimation pumps and cryopumps, are extremely selective. Efficient use of selective pumps requires that they be chosen to match the gas load. We present experimental data on some commonly encountered gas loads and discuss the choice of compatible pumps.

11514. Paulsen, P. J., Alvarez, R., Kelleher, D. E., **Determination of trace elements in zinc by isotope dilution spark source mass spectrometry,** *Spectrochim. Acta* **24B,** 535-544 (April 1969).

Key words: Electrodeposition; isotope dilution; preconcentration; spark source mass spectrometry; trace elements; zinc.

The applicability of the isotope dilution technique in spark source mass spectrometry has been investigated for the determination of Pb, Cu, Cd, Ag, Tl, and Sn in zinc metal. In the procedure developed, a solution of the zinc is spiked with known amounts of stable isotopes of the elements to be determined, and the elements are electrodeposited onto gold wires that subsequently serve as electrodes for the mass spectrographic isotopic analysis. Chemical operations, including isothermal distillation of reagents, dissolution of the zinc, and the electrodeposition step are conducted in a closed system to minimize contamination. The results of the analysis of two NBS zinc standard reference materials include determinations ranging from 11 ppm (11 μg/g) for Pb to as low as 0.02 ppm (20 ng/g) for Sn. It is concluded that this method is of general utility for simultaneous multi-element trace analysis and is especially applicable in providing much needed standardization in spark source mass spectrometry.

11515. Robbins, R. F., **Cryogenic properties of a polyurethane adhesive,** *J. Macromol. Sci.* **A3,** No. 7, 1367-1380 (Nov. 1969).

Key words: Adhesive; low temperature; mechanical properties; polymer; polyurethane; resilience; thermal properties.

Differential thermal analysis (DTA), rebound resilience, and tensile properties of a polyurethane adhesive were measured at cryogenic temperatures. The experimental methods are described, and test results which aid in evaluating the polyurethane for use at low temperatures are discussed. The DTA thermogram reveals that the glass transition temperature (T_g) is 235 K. The resilience profile indicates a resilience minimum (T_r) at 270 K and a frequency of 3800 Hz, which is consistent with the T_g measured by DTA. The low resilience below T_r, caused by secondary low-temperature transitions, shows the high energy absorption capabilities of the polyurethane. Considerable plastic flow at 195 K (40 K below T_g) is evidenced in the results of the tensile tests. The results of the three tests indicate that the polyurethane adhesive will perform well at low temperatures. The test methods should also be useful for evaluating the low-temperature performance of new polymers.

11516. Silverman, S., **The National Measurement System—a concept to assist the private sector,** *Mater. Res. Std.* **9,** No. 10, 11-14 (Oct. 1969).

Key words: Measurement; National Bureau of Standards; National Measurement System; national standards; self-calibration; standards, national; systems concept.

The concept of a National Measurement System, involving the entire complex of measurement activities within the United States, is developed. The central element of this Measurement System is the National Bureau of Standards. The role of NBS and of other functional elements of the System, such as private laboratories, is discussed.

11517. Simpson, A. U., Timmerhaus, K. D., Kreith, F., Jones, M. C., **Heat and mass transfer in dispersed, two-phase, single-component flow,** *Intern. J. Heat Mass Transfer* **12,** No. 9, 1141-1155 (Sept. 1969).

Key words: Boundary layer; computation; dispersed flow; heat transfer; solid-vapor; two-phase.

The process of heat transfer to a two-phase mixture of well-dispersed subliming particles and vapor, flowing over a heated surface, is analyzed. It is shown by a laminar boundary analysis that, when the surface-area per unit volume of the particle (or solid) phase is large enough, the phase change dominates the heat-transfer process and hastens the development of the thermal boundary layer. Under these conditions, the thermal boundary-layer thickness not only becomes uniform a short distance downstream from the starting point, but also is substantially less than it would be were the particle phase absent. For such systems, the equations describing the heat-transfer process can be considerably simplified and, if the physical properties of both phases are uniform, a remarkably simple solution results. For systems in which the physical properties are not uniform, a solution involving integration across the boundary layer is developed. The solutions are applicable to developing, as well as fully developed, laminar boundary layers over a flat plate; the solutions also approximate conditions in flow through a tube, provided that the tube radius is large compared to the thermal boundary-layer thickness. The predictions of this theoretical analysis agree satisfactorily with experimental results. With slight modification, the same approach may possibly be applicable for turbulent flow in the boundary layer.

11518. Smith, E. W., Cooper, J., Vidal, C. R., **A unified classical path treatment of Stark broadening in plasmas,** *Phys. Rev.* **185,** No. 1, 140-151 (Sept. 5, 1969).

Key words: Classical path; spectral line broadening.

A theoretical treatment of spectral line broadening in plasmas is developed using classical-path methods. This treatment unifies certain aspects of the familiar impact, one-electron, and relaxation theories to produce results which are valid from the line center to the far line wings where the electrons may behave quasistatically. Calculations of the Lyman-α line of hydrogen are used to illustrate the theory.

11519. Smith, R. V., **The influence of surface characteristics on the boiling of cryogenic fluids,** *J. Eng. Ind.* **91,** No. 4, 1217-1221 (Nov. 1969).

Key words: Boiling; boiling hysteresis; boiling inception; boiling-site spreading; radiation.

This paper reviews the influence of the characteristics of the solid surface on the boiling of cryogenic fluids. Particular emphasis is placed on papers presented in the cryogenics section of the 1968 Annual ASME meeting.

Hysteresis, boiling-site spreading and the influence of radiation on the surface are discussed in detail.

11520. Strobridge, T. R., **Refrigeration techniques,** *U.S. Bureau Mines Info. Circ.* No. 8417, pp. 39-56 (1969).

Key words: Applications; cryogenic; refrigeration; thermodynamic cycles.

The supply of helium accumulated through the conservation program has allowed technology in many disciplines to freely make use of the unique behavior of helium. Helium is the only fluid that can be conveniently used as a refrigerant below about 14 K and is often used at higher temperatures. The thermodynamic cycles that modern helium refrigerators utilize are reviewed. The Joule-Thomson process is important because it forms the lowest temperature stage of virtually all helium temperature refrigerators. The various processes and cycles for precooling the helium stream prior to the Joule-Thomson process form the essential differences between the closed cycle refrigerators operating today. Typical refrigeration and liquefaction facilities, both large and small, are discussed.

11521. Vidal, C. R., Cooper, J., **Heat pipe oven: a new, well-defined metal vapor device for spectroscopic measurements,** *J. Appl. Phys.* **40,** No. 8, 3370-3374 (July 1969).

Key words: Absorption spectroscopy; heat pipe; metal vapor device; oven.

A new, well-defined metal vapor device called the heat-pipe oven has been developed on the basis of the heat pipe, a heat conductive element designed by Grover and his co-workers in Los Alamos. It continuously generates homogeneous vapors of well-defined temperature, pressure, and optical path length. The vapor is confined by inert gas boundaries which remove the window problem and allow a direct pressure measurement without relying on vapor pressure curves. Due to the continuous evaporation and condensation the vapor purifies itself during operation.

11522. Wampler, R. H., **An evaluation of linear least squares computer programs: A summary report,** (Proc. 14th Conf. Design of Experiments in Army Research Development and Testing, Edgewood Arsenal, Md., October 23, 1968), *ARO-D Report* **69-2,** 103-126 (U.S. Army Research Office-Durham, Durham, North Carolina, Sept. 1969).

Key words: Computer programs; curve fitting; Gram-Schmidt orthogonalization; Householder transformations; iterative refinement; least squares; linear equations; orthogonalization; orthogonal polynomials; regression; rounding error; stepwise regression.

Two linear least squares test problems based on fifth degree polynomials have been run on more than twenty different computer programs in order to assess their numerical accuracy. Among the programs tested were representatives from various statistical packages as well as some from the SHARE library. Essentially four different algorithms were used in the various programs to obtain the coefficients of the least squares fits. The tests were run on several different computers, in double precision as well as single precision. By comparing the coefficients reported, it was found that those programs using orthogonal Householder transformations or Gram-Schmidt orthonormalization were much more accurate than those using elimination algorithms. Programs using orthogonal polynomials (suitable only for polynomial fits) also proved to be superior to those using elimination algorithms. The most successful programs accumulated inner products in double precision and made use of iterative refinement procedures. In a number of programs, the coefficients reported in one test problem were sometimes completely erroneous, containing not even one correct significant digit.

11523. Weber, L. A., **Saturation densities of oxygen in the critical region,** *Physics Letters* **30A,** No. 7, 390-391 (Dec. 1, 1969).

Key words: Critical density; critical point; critical temperature; oxygen; properties of fluids; P-V-T, saturation densities.

Dielectric measurements have been used to determine the saturation densities of oxygen in the critical region. Analysis of the data yields a value of 154.576 K for T_c and 0.4362 g/cm^3 for ρ_c. The critical index $\beta=0.353$

11524. Wiederhorn, S. M., **Crack propagation in polycrystalline ceramics,** (Proc. 15th Sagamore Army Materials Research Conf., Sagamore Conference Center, Raquette Lake, New York, Aug. 20-23, 1968), Chapter in *Ultrafine-Grain Ceramics* **15,** 317-338 (Syracuse University Press, Syracuse, N.Y., 1970).

Key words: Ceramics; fracture; fracture surface energy; strength; thermal shock.

In this chapter, the strength and shock resistance of ceramic materials will be related to microstructural details and the energy necessary to form fracture surfaces. The influence of grain size, grain orientation, crystal anisotropy and residual stresses on crack propagation will be discussed. It will be argued that the strength of ceramic materials is closely related to the grain boundary or single-crystal fracture surface energy, while shock resistance is related to the surface energy required to propagate large cracks through polycrystalline materials. The use of fracture surface energies as a research technique and as a design parameter will be discussed.

11525. Wilson, W. K., **Reflections on the stability of paper,** *Restaurator* **1,** No. 2, 79-86 (1969).

Key words: Degradation; paper; preservation of records; records; stability.

Variables in the composition of paper are discussed in relation to stability, and new approaches to research on preservation of records are described.

11526. Wood, R. E., Hamer, W. J., **Theoretical electromotive forces of metal-halogen cells: Some recalculations based on recent data,** *J. Electrochem. Soc.* **117,** No. 1, 82-83 (Jan. 1970).

Key words: Cells; emfs; free energies of formation; fused salts; halides; thermodynamics.

Comparison of the theoretical emfs for cells containing a single solid or molten halide published by Hamer, Malmberg and Rubin in 1956 and 1965 with emfs calculated from tabulations in the JANAF tables published in 1965, 1966, 1967 and 1968 reveals some rather large discrepancies. This note tabulates the 34 cases in which such discrepancies were found to exceed 100 millivolts, discrepancies equivalent to 2.3 kcal equiv^{-1} or more.

11527. Yakowitz, H., **The divergent beam x-ray technique,** Chapter in *Advances in Electronics and Electron Physics, Suppl.* **6,** *Electron Probe Microanalysis,* A. J. Toksimis and L.

L. Marton, eds., pp. 361-431 (Academic Press Inc., New York, N.Y., 1969).

Key words: Kossel method; x-ray microdiffraction.

This is a review paper discussing the technique of divergent beam (Kossel) x-ray diffraction. The Kossel method is studied with regard to line intensities, photographic contrast, data reduction, specimen preparation, and contribution to scientific research.

11528. Adams, J. W., Jarvis, S., Jr., **Current distribution in barretters and its application to microwave power measurements,** *IEEE Trans. Micro. Theory Tech.* **MTT-17,** No. 10, 778-785 (Oct. 1969).

Key words: Barretter; bolometer; current distribution in barretter; microwave power measurement; substitution error.

This paper describes a mathematical analysis for determining the microwave current distribution in a barretter in a rectangular waveguide. This distribution, when used with another analysis which calculates substitution error for any given current distribution, provides a missing step necessary for the calibration of microwave and millimeterwave barretters for absolute power measurements.

11529. Balcom, M. M., **Influence of red and blue pre-adaptation on hue matching of purple samples,** *J. Opt. Soc. Am.* **60,** No. 1, 118-121 (Jan. 1970).

Key words: Adaptation; color; hue; vision.

This experiment was designed to show the effect, if any, of chromatic adaptation on hue matching of purple painted samples of different saturations. Five experienced observers were adapted for 1 min to a red field, then asked to find the hue match for each of three test samples from among a set of samples representing the complete hue circuit in 100 steps at middle saturation. The three test samples were of slightly greater saturation and representative of a range of purple samples. The entire procedure was repeated with blue and neutral pre-adapting fields, all under source C illumination. Results indicated that pre-adaptation did influence the hue-match selections, the average red-blue adaptive shift being about one Munsell hue step. Observers made systematically different hue matches for the same test sample, in accordance with their ages. A method for determining graphically the state of adaptation at the time when the hue judgments were made showed that the chromaticity of the test samples was at least as influential as either the neutral surround used or the pre-adaptation stimuli.

11530. Branscomb, L. M., **Truth in packaging of scientific information,** *Meas. Data* **3,** No. 5, 104-105 (Sept.-Oct. 1969).

Key words: Reviews; science information; scientific literature.

This is an edited version of a talk presented to the Precision Measurements Association meeting in Boulder, Colorado, August 28, 1968.

11531. Brauer, G. M., Termini, D. J., Burns, C. L., **Characterization of components of dental materials and components of tooth structure by differential thermal analysis,** *J. Dental Res.* **49,** No. 1, 100-110 (Feb. 1970).

Key words: Characterization of dental materials; components of tooth structure; dental materials; differential thermal analysis (DTA); differential thermal analysis of calcium phosphates.

Differential thermal analysis (DTA) has been used to characterize a variety of dental materials and the components of tooth structure. The technic is useful for the rapid comparison of similar materials, quality control, measurement of melting ranges, and the study of reactions occurring at elevated temperatures.

11532. Brown, D. W., Wall, L. A., **Glass transition temperatures of several fluorine-containing polymers,** *J. Polymer Sci.: Part A-2,* **7,** 601-608 (1969).

Key words: Fluorine-containing polymers; fluorine-containing styrene; glass temperature; high pressure; perfluoro-α,ω-dienes; perfluoro-α-olefins.

The glass transition temperatures T_g of several fluorine-containing polymers were determined by use of the differential scanning calorimeter. Values between −3 and 230 °C were obtained. In polymers of α-olefins, T_g increases with the fluorine content of the backbone and the length of the *n*-perfluoroalkyl branch. In styrene polymers T_g also is higher if the backbone contains fluorine but nearly the same T_g's are found for polymers with phenyl and pentafluorophenyl groups. Saturated polymers of perfluoro-α,ω-dienes have lower T_g's than polyperfluoro-α-olefins. The T_g's of chloroperfluoropolymers are higher than those of perfluoropolymers. Polyperfluoropentadiene-1,3 has the lowest T_g of the polymers examined. Polyperfluoropentadiene-1,3 forms by 1,4-addition.

11533. Demtroder, W., McClintock, M., Zare, R. N., **Spectroscopy of Na_2 using laser-induced fluorescence,** *J. Chem. Phys.* **51,** No. 12, 5495-5508 (Dec. 1969).

Key words: Alkali dimers; laser-induced fluorescence; molecular fluorescence; molecular spectroscopy; Na_2; resonance fluorescence.

The argon-ion laser lines at 4658, 4727, 4765, 4880, 4965, 5017, and 5145 Å are each found to excite one or more resonance fluorescence series of the Na_2 $(X\,^1\Sigma_g^+ - B^1\Pi_u)$ blue-green band system. Altogether, 19 different fluorescence progressions have been indentified and assigned v, J quantum numbers. The absolute wavenumbers of many of these emission lines have been measured interferometrically using a Fabry-Perot etalon crossed with a Bass-Kessler type spectrograph. A revised set of spectroscopic constants has been determined for both the upper and lower states which reproduce the observed term energies to better than 0.1 cm^{-1} on the average. Using these improved spectroscopic data, potential curves have been constructed for the B and X states of Na_2 by the Rydberg-Klein-Rees method. These potential curves are used in turn to compute Franck-Condon factors for the Na_2 B−X band system.

11534. Dickens, B., Brown, W. E., **The crystal structure of calcium carbonate hexahydrate at ∼−120°,** *Inorg. Chem.* **9,** No. 3, 480-486 (Mar. 1970).

Key words: Calcium phosphate; calcium phosphate-calcium silicate solid solution; calcium phosphosilicates; calcium silicates; crystal structures; glaserite; hydroxyapatite; single crystal x-ray diffraction.

The crystal structure of $CaCO_3\,6H_2O$ has been determined from 1420 x-ray diffraction data collected photographically by the oscillation technique from a single crystal held at ∼−120°. The unit cell parameters are $a = 8.87$ (2) Å, $b = 8.23$ (1) Å, $c = 11.02$ (2) Å, and $\beta = 110.2$ (2)°, and the space group is C2/c with $Z = 4$. The calculated density at ∼−120° is 1.80 g cm^{-3}, and the observed density at ∼0° is 1.82 g cm^{-3}. The final R factor is 0.10. The structure contains discrete $CaCO_3$ ion pairs, each surrounded by an envelope of 18 water molecules. Thus, Ca^{2+} is coordinated to only one CO_3^{2-}. Six of the surrounding H_2O molecules are bonded to Ca^{2+}, eight are hydrogen bonded to oxygens of the CO_3^{2-} group, and four are bonded to adjacent ion pairs and to other water molecules in the envelope. $CaCO_3\,6H_2O$

was found to be more stable than $CaCO_3\,H_2O$ in water near 0°. The formation of $CaCO_3\,6H_2O$ from an equivalent amount of calcite ($CaCO_3$) and water is accompained by a 20% decrease in volume. This may be important in explaining the scarcity of calcareous material in life in the ocean depths.

11535. Fatiadi, A. J., **Conversion of certain cyclic phenylhydrazino derivatives into phenylazo compounds with periodic acid,** *J. Org. Chem.* **35,** No. 3, 831-833 (Mar. 1970).

Key words: Action; cyclohexanedione; ene-hydrazine; enol; periodic acid; phenylazo compounds; phenylhydrazine.

Model ene-hydrazines (3-oxo-1-phenylhydrazino-1-cyclohexene and 5,5-dimethyl-3-oxo-1-phenylhydrazino-1-cyclohexene) have been prepared from the corresponding 1,3-cyclohexanediones (or their enols) and phenylhydrazine. Treatment of these ene-hydrazines with periodic acid at room temperature produces the corresponding azo compounds in 90 percent yield. It is probable that the action of periodic acid on a phenylhydrazino group proceeds by simultaneous attack of an electrophilic and a nucleophilic species (present in aqueous acetic—periodic acid) on vinyl and phenyl NH groups, respectively.

11536. Freeman, D. H., Currie, L. A., Kuehner, E. C., Dixon, H. D., Paulson, R. A., **Development and characterization of ion-exchange bead microstandards,** *Anal. Chem.* **42,** No. 2, 203-209 (Feb. 1970).

Key words: Ion exchange; microstandards; nanogram.

The encapsulation of Na or Ca by ion exchange beads is investigated in the counterion mass range below one nanogram. Preparative methods are described for obtaining the exchange in a pure counterion form and for subsequent prevention of ion exchange so that the isolation of a single bead is possible in the absence of significant contamination. Activation analysis indicated that the network heterogeneity was characterized by a 5% relative standard deviation for Na in measurements extending to 3×10^{-12} grams. A bead diameter measurement is equivalent to a counterion mass determination and this opens the door to the use of the beads as microstandards in the mass region where no other methods are applicable.

11537. Freeman, D. H., Goldstein, S., Schmuckler, G., **Homogeneous sulfonation of styrene-divinylbenzene copolymers with oleum in organic solvents,** *Israel J. Chem.* **7,** No. 6, 741-749 (1969).

Key words: Cation exchangers; ion exchangers; oleum; sulfonation.

In order to obtain homogeneously sulfonated cation exchangers, the copolymers were sulfonated by oleum in a mixture of methylene-chloride and nitromethane. The influences of the chemical interaction and of the diffusion process on the kinetic behavior of these systems were investigated, and it was shown that raising the temperature of the sulfonation mixture markedly increases the chemical reaction rate, while the effect on the diffusion is small. A curve-fitting technique was used for the interpretation of the degree-of-sulfonation-vs.-time curves. These investigations served as guidelines for the subsequent preparation of homogeneous highly sulfonated copolymers.

11538. Gadzuk, J. W., **Resonance tunneling through impurity states in metal-insulator-metal junctions,** *J. Appl. Phys.* **41,** No. 1, 286-291 (Jan. 1970).

Key words: Electron tunneling; impurities; junctions; metal-insulator-metal structures.

Motivated by the recent work of Parker and Mead on the effects of impurity trapping states in Schottky barriers, a theory of resonance tunneling through adsorbed atoms in field emission is modified to treat resonance tunneling through isolated and uniformly distributed impurities in the insulating layer of a metal-insulator-metal tunnel junction. In analogy with the magnetic impurity tunneling theory of Appelbaum, the effects of resonant tunneling through impurity states open up new tunneling channels with a concomitant change of slope in the current-voltage characteristics. These changes should be apparent as definite structure in curves of $d\sigma/dV$ versus voltage although depending upon the impurity concentrations and impurity level positions relative to the Fermi levels of the two metals, the height of the structure reflecting the impurity energy level spectrum may not rise above the noise level. In addition it is seen that the presence of impurities can alter the total conductance of a M-I-M tunnel junction. The new conductance versus voltage characteristics are calculated.

11539. Green, J. A. S., Mengelberg, H. D., Yolken, H. T., **Oxide growth on copper and alpha-brasses in aqueous ammonia,** *J. Electrochem. Soc.* **117,** No. 4, 433-437 (Apr. 1970).

Key words: Alpha-brass; copper; ellipsometry; oxide-growth; season-cracking; stress-corrosion.

An ellipsometric study of the kinetics of oxide growth for pure copper and a series of alpha-brasses immersed in tarnishing ammoniacal environments has established that the growth of the oxide, shown to be cuprous oxide, obeys a linear law in each case, and that the rate of growth increases significantly with (*a*) increasing zinc content of the solid, (*b*) increasing temperature, and (*c*) the application of anodic potentials. On the basis of these results it is suggested that the oxide is porous and that oxide growth involves the dissolution of metal ions at the base of the pore (anodic reaction) and their deposition at the oxide surface (cathodic reaction), electrons flowing through the oxide film. The influence of zinc content on the oxide-growth rate is attributed to its effect on the dissolution kinetics.

11540. Heinrich, K. F. J., Fiori, C., Yakowitz, H., **Image-formation technique for scanning electron microscopy and electron probe microanalysis,** *Science* **167,** 1129-1131 (Feb. 20, 1970).

Key words: Derivative signal; electron probe; image; scanning electron microscope; secondary electrons; target current.

A technique is described for producing improved topographic images on the scanning electron microscope and the scanning electron probe microanalyzer. In this technique, the brightness of the oscilloscope is modulated by a signal obtained by mixing the signal (from secondary electrons or target current) with its first derivative. This enhances minor topographic features which are poorly reproduced in the conventional technique.

11541. Ireland, C. T., Ku, H. H., Kullback, S., **Symmetry and marginal homogeneity of an r × r contingency table,** *J. Am. Statist. Assoc.* **64,** 1323-1341 (Dec. 1969).

Key words: Contingency table analysis; homogeneity of marginals; minimum discrimination information estimation; test for symmetry.

The principle of minimum discrimination information estimation is employed to obtain RBAN (Regular Best Asymptotically Normal) estimates of the cell frequencies of an $r \times r$ contingency table under hypotheses of either symmetry or marginal homogeneity. For the latter, a convergent iterative procedure is given to compute the estimates. The associated minimum discrimination information statistics are distributed asymptotically as χ^2 under the null hypotheses. The procedures differ from those previously presented in the literature and permit of extension to multidimensional contingency tables. An example is given.

11542. Kaufman, V., Humphreys, C. J., **Accurate energy levels and calculated wavelengths of ^{86}Kr I,** *J. Opt. Soc. Am.* **59,** No. 12, 1614-1628 (Dec. 1969).

Key words: Calculated wavelengths; energy levels; krypton 86; standard wavelengths.

A total of about 240 spectral lines of ^{86}Kr I has been measured interferometrically during the past decade. Some have been measured in only one laboratory while others have been measured in as many as 12. On the whole, the agreement is good, but some discrepancies appear. For this work, almost all of the wavelengths have been averaged and used for the determination of a best set of energy-level values for this isotope of krypton. Forty-five even and 66 odd levels have been calculated by the method of least squares, with uncertainties ranging from ±0.0001 to ±0.0016 cm^{-1}. These interferometrically determined levels have, in turn, been used to calculate a completely consistent set of wavelengths that are preferable to any single set of measurements or averages of measurements of ^{86}Kr I. The list of 530 lines contains only those calculable transitions that have been observed from krypton sources in the spectral region 3300-40 700 Å. With the exception of a number of weak lines and some close pairs, the final list of wavelengths is recommended for consideration for adoption as secondary standards.

11543. Kilgore, S. B., **Electronic circuit breaker for motor load protection,** *Rev. Sci. Instr.* **41,** No. 1, 40-41 (Jan. 1970).

Key words: Electronic circuit breaker; mechanical load protection; surge current; time delay.

An electronic circuit breaker, designed to switch off the power to an electric motor when the mechanical load increases beyond the normal load, is described. The circuit operates rapidly and can sense an increase in mechanical load before it reaches destructive proportions. The sensitivity of the electronic circuit makes it necessary to incorporate a time delay that prevents the initial surge current from turning the motor off before it gets started.

11544. Klein, R., Scheer, M. D., **Addition of oxygen atoms to olefins at low temperature. IV. Rearrangements,** *J. Phys. Chem.* **74,** No. 3, 613-616 (Feb. 5, 1970).

Key words: Low temperature; olefins; oxygen atoms.

Rearrangements in the $O(^3P)$ atom addition to internal, straight-chain olefins involve, as one of the processes, internal rotations resulting in configurational changes. Symmetrical *cis*-olefins at 90 K were found to show greater stereospecificity in the oxygen atom addition reaction as the chain length was increased. Rearrangements involving migration of alkyl groups and localization of oxygen on one of the carbon atoms of the olefinic pair occur in a concerted manner. This was shown from the reactions of 3-ethyl-2-methyl-2-pentene and two of its isomers. Clearly, independent rates cannot be associated with migrating alkyl groups, and additional factors, other than electron density, determine the position of addition of the oxygen atom.

11545. Krauss, M., Mielczarek, S. R., **Minima in generalized oscillator strengths; C_2H_4,** *J. Chem. Phys.* **51,** No. 12, 5241-5243 (Dec. 15, 1969).

Key words: Configurational mixing; C_2H_4; differential cross section; electron impact; excitation; oscillator strength.

A characteristic of electron impact excitation of low-lying Rydberg states is a minimum in the generalized oscillator strength as a function of *K*, the momentum transfer. This characteristic is used as a probe of the Rydberg character of four transitions in C_2H_4. Three, the $^1A_g \rightarrow {}^1B_{3u}(\pi \rightarrow 3s+3s)$, $^1A_g \rightarrow {}^1B_{3u}(\pi \rightarrow 3p_z-3p_z)$, and $^1A_g \rightarrow {}^1B_{3u}(\pi \rightarrow 4s)$ transitions, have long been identified as Rydberg and are found to exhibit the characteristic minimum. A fourth transition $^1A_g \rightarrow {}^1B_{1u}(\pi \rightarrow \pi^*)$ is normally termed a valence excitation, and a theoretical calculation using Hartree-Fock molecular orbitals had predicted no minimum. For an energy loss of 8.0 eV which is identified with the valence transition a definite minimum is observed. Speculation on the source of this anomaly centers on a type of valence-Rydberg configurational mixing which can occur in many molecules. It is suggested that the presence or absence of minima in generalized oscillator strength curves be used to probe this aspect of the character of the excited state.

11546. Latanision, R. M., **On the dislocation distribution near the surface of lightly deformed copper single crystals,** *Scripta Met.* **3,** No. 7, 465-470 (July 1969).

Key words: "Debris layer"; edge dislocation; near-surface source; screw dislocation; single crystals; surface source.

Two recent and essentially identical etch-pitting studies on oriented copper single crystals have produced contradictory results. An explanation for the discrepancy is not obvious, but the results of these investigations may be interpreted in terms of either the surface "debris" layer hypothesis or the activation of surface or near-surface dislocation sources. The purpose of this note is to emphasize the ambiguity involved in such studies.

11547. Lechner, R. E., Rowe, J. M., Sköld, K., Rush, J. J., **Study of molecular reorientation in solid neopentane by quasielastic neutron scattering,** *J. Chem. Phys. Letters* **4,** No. 7, 444-448 (Dec. 15, 1969).

Key words: Activation energy; Cold neutron; correlation time; diffusion constant; molecular reorientation; neopentane; neutron scattering; plastic crystal; quasielastic.

Results of cold neutron scattering by plastic neopentane at several temperatures are presented. The measured quasielastic peak widths are compared with calculations for two simple models of molecular reorientation. An activation energy for reorientation of 0.88 ± 0.11 kcal/mole is derived.

11548. Lide, D. R., Jr., **Determination of anharmonic potential constants in linear XYZ molecules,** *J. Mol. Spectr.* **33,** No. 3, 448-459 (Mar. 1970).

Key words: Anharmonic constants; Fermi resonance; linear molecules; vibrational potential function; vibration-rotation interactions.

A method for determining the anharmonic potential constants k_{122}, k_{322}, and k_{2222} of linear triatomic molecules is formulated. The calculation makes use of experimental rotational constants B_v and vibrational term values G_v of low-lying vibrational levels. The anharmonic (Fermi) interactions among the triad (10^00), (02^00), (00^01) are treated explicitly, but otherwise the calculation is based on the usual second-order theory. The method is applied to four molecules for which sufficiently accurate experimental data are available: N_2O, ClCN, BrCN, and OCS. The internal consistency of the calculation is not very satisfactory, which suggests that higher-order terms in the vibration-rotation Hamiltonian cannot be neglected. However, a set of anharmonic constants is obtained for each molecule which is felt to be more reliable than those previously published.

11549. McClintock, M., Demtroder, W., Zare, R. N., **Level crossing studies of Na_2 using laser-induced fluorescence,** *J. Chem. Phys.* **51,** No. 12, 5509-5521 (Dec. 1969).

Key words: Laser-induced fluorescence; laser-molecular level crossing; level crossing; molecular fluorescence; molecular spectroscopy; Na_2.

The technique of using laser excitation to study level crossings in molecules has been developed and used to determine the radiative lifetime of an excited state of Na_2. Optical detection of level crossing in the $v' = 10$, $J' = 12$ level of the $B\,^1\Pi_u$ electronic state of Na_2, excited by the 4765-Å argon-ion laser line, has resulted in a precise measurement of the product $g_\tau = 4.11 \pm 0.12 \times 10^{-11}$ sec, corresponding to a magnetic field half-width of 1385 × 42 G. If the g value is calculated assuming Hund's coupling case (a), the radiative lifetime is determined to be $\tau = 6.41 \pm 0.38 \times 10^{-9}$ sec. The influence of molecular hyperfine structure on this measurement is discussed and is found in general to contribute little uncertainty to the value of the radiative lifetime, provided the rotational angular momentum is much larger than the nuclear spin and/or provided the hyperfine interaction is much smaller than the natural width of the excited state.

11550. McCrackin, F. L., **Analyses and corrections of instrumental errors in ellipsometry,** *J. Opt. Soc. Am.* **60,** No. 1, 57-63 (Jan. 1970).

Key words: Birefringence; ellipsometer; thin films.

Expressions for the errors produced in an ellipsometer due to an imperfect compensator, due to birefringence in windows of a cell containing the sample, and due to tilting of the sample are derived. Methods of analyzing the ellipsometer readings to eliminate these errors are given.

11551. McLaughlin, W. L., Hussmann, E. K., **The measurement of electron and gamma-ray dose distributions in various media,** (Proc. Symp. Utilization of Large Radiation Sources and Accelerators in Industrial Processing, Munich, Germany, Aug. 18-22, 1969), Chapter in *Large Radiation Sources for Industrial Processes,* **IAEA-SM-123/43,** pp. 579-590 (International Atomic Energy Agency, Vienna, Austria, 1969).

Key words: Depth dose; dose distributions; dosimetry; dyes; electron beams; films; gamma rays; microdosimetry; radiographic imaging.

New radiochromic dye films and gels are proposed as simple and relatively accurate devices for imaging and determining the energy deposited locally at different depths and across interfaces of various irradiated media. Depth-dose measurements show remarkable agreement with theoretical computations in various plastics and aluminum, even near the end of the electron range, indicating that the dosimeter response is representative of the energy imparted to the medium over a wide range of electron energies.

11552. Unassigned.

11553. Pizer, R. S., Spinner, S., **An apparatus for determining the actual footprint area of tires,** *Mater. Res. Std.* **10,** No. 2, 20-23 (Feb. 1970).

Key words: Contact area; silicon solar cell; tires; tire footprint.

An apparatus for measuring the actual contact area of tires regardless of their tread design is described. The procedure is both rapid and accurate. The method utilizes a bank of lights, an opal glass plate, a simple light focusing system, and a silicon solar cell which linearly transforms the incident light to an electrical current. The reduction in current is the measure of the true contact area of the tire.

11554. Potzick, J., **Low-frequency sine-wave oscillator,** *EEE* **18,** No. 3, 130 (Mactier Publishing Corp., Mar. 1970).

Key words: Low frequency oscillator; oscillator.

A simple, inexpensive, low-frequency oscillator which generates a fairly low distortion sine wave at a frequency of about one hertz is described.

11555. Powell, C. J., **Analysis of optical- and inelastic-electron-scattering data. II. Application to Al,** *J. Opt. Soc. Am.* **60,** No. 1, 78-93 (Jan. 1970).

Key words: Complex dielectric constant; electron-energy-loss; electronic band structure; infrared; least-squares fit to optical data; optical constants; reflectance; ultraviolet; visible.

Optical and electron energy-loss data for aluminum between 0.04 and 72 eV have been critically analyzed and used to test the validity of models for $\epsilon(\omega)$, the complex frequency-dependent dielectric constant. Experimental data and models for $\epsilon(\omega)$ can be effectively compared by use of a nonlinear least-squares computer program and, at least in simple cases, the model parameters have physical significance. Though aluminum has been widely regarded as a relatively ideal free-electron metal, it has been found that a Drude model for $\epsilon(\omega)$ does not adequately describe the observed data. Deviations from the Drude model for photon energies greater than about 1 eV have been interpreted in terms of the effects of interband-electronic transitions and a significant L-shell contribution to the real part of $\epsilon(\omega)$ between 10 and 72 eV. From a fit of reflectance data between 0.2 and 12 eV it has been possible to derive parameters describing the interband-transition contribution $\epsilon^{(b)}(\omega)$ to $\epsilon(\omega)$; the imaginary part of $\epsilon^{(b)}(\omega)$ does not differ significantly from calculations based on the aluminum band structure. Optical constants have been derived in the range of fit and agree closely with the measurements of Hass and Waylonis between 1.9 and 5.6 eV. For photon energies less than 0.2 eV, the reflectance data can be fitted by the empirical formulation of Roberts. The optical absorption for photon energies greater than 12 eV is monotonic and greater than that expected from the tails of the electronic transitions at 1.5 – 2eV.

11556. Powell, C. J., **Analysis of optical- and inelastic-electron-scattering data. III. Reflectance data for beryllium, germanium, antimony, and bismuth,** *J. Opt. Soc. Am.* **60,** No. 2, 214-220 (Feb. 1970).

Key words: Antimony; beryllium; bismuth; complex dielectric constant; germanium; least-squares fit to reflectance; optical constants; reflectance; ultraviolet.

A procedure is described for simultaneously fitting reflectance data obtained for various photon energies and angles of incidence using a simple physical model for $\epsilon(\omega)$, the complex frequency-dependent dielectric constant. The mutual consistency of the model and of the experimental data is tested, within the accuracy of each measurement. As an example of the technique, reflectance data in the vacuum ultraviolet obtained by Toots, Fowler and Marton for beryllium, germanium, antimony and bismuth have been satisfactorily fitted. The model parameters have been used to derive the optical constants n and k (in satisfactory agreement with conventional determinations) and can be readily related to other relevant experimental results or theoretical calculations of $\epsilon(\omega)$ if these are available.

11557. Reader, J. Epstein, G. L., **Revised $4p^5\ ^2P^\circ_{1/2,3/3}$ splitting of Y v,** *J. Opt. Soc. Am.* **60,** No. 1, 140 (Jan. 1970).

Key words: Atomic spectroscopy; energy levels; resonance lines; yttrium.

The two resonance lines of Y v consisting of transitions from $4s4p^6\ ^2S_{1/2}$ to $4s^24p^5\ ^2P^\circ_{1/2,3/2}$ have been observed for the first time. Measurement of the wave number difference between these two lines proves that the existing analysis of the Y v spectrum by Paul and Rense [Phys. Rev. **56,** 1110 (1939)] is entirely in error; as had been suspected by Edlén [in Atomic Spectra, Handbuch der Physik (Springer-Verlag, Berlin, 1964), Vol. XXVII, p. 185.]

11558. Roth, R. S., Stephenson, N. C., **Chemical and structural investigations in the Ta_2O_5-WO_3 system,** (Proc. Institute for Advanced Study on the Chemistry of Extended Defects in Non-Metallic Solids, Scottsdale, Arizona, April 16-26, 1969), Chapter in *The Chemistry of Extended Defects in Non-Metal-*

lic Solids, L. Eyring and M. O'Keeffee, eds., pp. 167-182 (North Holland Publ. Co., Amsterdam, The Netherlands, 1970).

Key words: Crystal structure; non-stoichiometry; order oxygen vacancies; tantalum oxide; tantulum tungsten system.

Crystal structures have been determined for the compounds $Ta_{22}W_4O_{67}$, $Ta_{30}W_2O_{81}$, $Ta_{74}W_2O_{191}$, and Ta_2O_5. These compounds are stable phases in the Ta_2O_5-WO_3 system and have unit-cells which are based, respectively, on 13, 8, 19 and 11 UO_3-type subcell units. Metal atoms are either octahedrally coordinated to six oxygen atoms or else surrounded by seven oxygen atoms in the form of a pentagonal bipyramid.

On the basis of these structures a building-block scheme is developed which enables the *ideal*, or undistorted, structure to be predicted for any member of the hundreds of compounds which form a continuous series of structures in the region $Ta_2O_5 - 11Ta_2O_5 \cdot 4WO_3$.

Anionic packing distortions occur in the *ideal* structures. In the *real* structures these distortions are minimized by a reduction in the coordination number of *some* seven-coordinated metal atoms. These atoms form distortion-sheets throughout the structure. The importance and distribution of these distortion-sheets is discussed.

11559. Simpson, J. A., **Electron impact spectroscopy,** (Proc. 10th Symp. on Electron, Ion & Laser Beam Technology, Gaithersburg, Md., May 21-23, 1969), Chapter in *Record of 10th Symposium, Electron, Ion, and Laser Beam Technology*, L. Marton, ed., pp. 345-352 (San Francisco Press, San Francisco, Calif., 1969).

Key words: Chemical analysis; electron impact spectrometer; uv absorption.

Recent developments in electron spectrometer design have made the application of inelastic electron scattering measurements to gas analysis competitive with other techniques. The energy distribution of electrons of an initially monoenergetic electron beam after an encounter with a gas target (the loss spectrum) contains the optical absorption spectrum of the gas. The absorption data extend from the extreme vacuum ultraviolet into the visible with an energy resolution comparable to a 1/2-meter optical grating spectrometer. Its response is linear with concentration over a very wide range and contains between 10^3 and 10^4 resolution widths. This spectrum, by revealing the valence energy states of the gas, is the most intrinsic possible "fingerprint" of the atom or molecule. An instrument has been built to explore the potentialities of this method. The instrument is described and its performance as a trace analyzer for air pollution studies discussed.

11560. Snelleman, W., Menis, O., Rains, T. C., Yee, K. W., Cook, H. D., **Flame emission spectrometry with repetitive optical scanning in the derivative mode,** *Anal. Chem.* **42,** No. 3, 394-398 (Mar. 1970).

Key words: Ac scan; derivative mode; design; detection limits; flame emission spectrometry; interferences; matrix; microsamples.

A flame emission spectrometer using a rapid repetitive scan of a narrow wavelength region has been developed. By this method of wavelength scanning the second derivative of the output intensity is measured. The use of this approach to minimizing spectral interference in matrices and the use of microsamples greatly enhance the potentialities for flame emission spectrometry, and minimizes the need for a monochromator of high resolving power. A quartz plate, made to vibrate at 145 Hz, is mounted behind the entrance slit of the monochromator. The ac amplifier is synchronized with the oscillations of the quartz plate. When the amplifier is tuned to twice the frequency of vibration, the second derivative of the spectrum is obtained. This permits the measurement of weak line spectra nested in or on a broad band or continuum. It is demonstrated that spectral interference due to CaOH bands and/or a continuum are minimized in the measurement of barium. The elimination of interferences from bands and flame structure led to an improvement in detection limits of alkali and alkaline earth elements in the presence of many matrix ions. An analysis can be performed with 50 μl of solution which makes it applicable to biochemical and air pollution studies.

11561. Swartz, J. C., Swartzendruber, L. J., Bennett, L. H., Watson, R. E., **Nuclear magnetic resonance of ^{57}Fe in the paramagnetic alloys $TiFe_{1-x}Co_x$,** *Phys. Rev.* **1,** No. 1, 146-152 (Jan. 1, 1970).

Key words: Electronic structure; Knight shift; nuclear magnetic resonance; nuclear moment; TiFe; ^{57}Fe.

Nuclear magnetic resonances (NMR) of ^{57}Fe in isotopically enriched specimens of TiFe, $TiFe_{0.8}Co_{0.2}$, and $FeCl_3$, and of Ti in TiCo are reported. The results supplement existing Fe Mössbauer and Co NMR information on the pseudobinary $TiFe_{1-x}Co_x$. The Knight shift (and estimated uncertainty) of iron in TiFe is $+(1.29 \pm 0.03)\%$ at room temperature and $+(1.34 \pm 0.03)\%$ at 77 K, yielding a hyperfine coupling constant of $+(3 \pm 2)$ kG/μ_B per formula unit. Similar values are obtained for iron in $TiFe_{0.8}Co_{0.2}$. The Knight shift of Ti in TiCo is $+(0.07 \pm 0.02)\%$ at room temperature, and $-(0.06 \pm 0.03)\%$ at 77 K, yielding a hyperfine coupling constant of $-(12 \pm 3)$ kG/μ_B per formula unit for Ti in TiCo, contrasting with a near-zero coupling constant for Ti in TiFe. Both the orbital shifts and the *d*-spin hyperfine coupling constants for the Fe and Ti sites are much less dependent on cobalt concentration than these same quantities at the cobalt site. The NMR results on the three constituents of $TiFe_{1-x}Co_x$ suggest: (i) *s-d* admixture in the wave-function character at the Fermi surface for the (Fe,Co) sublattice, (ii) greater *s* admixture and perhaps a greater *d*-spin moment at an iron site than at a cobalt site in the iron-rich compounds, and (iii) a nuclear moment for cobalt corresponding to a nuclear gyromagnetic ratio $\gamma = 2\pi \times 1.003$ kHz/G. The Knight shift of dilute Fe in Ti as measured by the Mössbauer effect is $(0 \pm 1)\%$. The chemical shift of Fe in enriched aqueous $FeCl_3$ is found by NMR to be $+(0.40 \pm 0.04)\%$.

11562. Tighe, N. J., Kreglo, J. R., Jr., **Electron microscopy of periclase brick,** *J. Am. Ceram. Soc.* **49,** No. 2, 188-192 (Feb. 7, 1970).

Key words: Ceramic; electron microscopy, MgO; microstructure; sea-water periclase.

Transmission electron microscopy was used to study microstructure of sea-water periclase brick. The material contained 98.0% MgO and had a porosity of 19%. Specimens were cut from the brick and thinned for microscopy by ionic bombardment. MgO was present as single grains (20 to 90 μm) and as a fine precipitate (~100 Å) in an amorphous matrix. Dislocations in MgO grains were decorated with impurity precipitates. Forsterite, monticellite and glass were found as second phase regions.

11563. Waclawski, B. J., Hughey, L. R., **Adsorption of water vapor on polycrystalline tungsten,** *Surface Sci.* **19,** 464-468 (1970).

Key words: Adsorption; hydrogen evolution; polycrystalline tungsten; room temperature; ultra-high vacuum; water vapor; work function.

Following an induction period, a spontaneous evolution of hydrogen was observed to occur in the initial stages of adsorption at room temperature when polycrystalline tungsten was exposed to water vapor. Concurrent photoemission measurements indicated that a change in the work function of the sample occurred during the hydrogen evolution. Calculations of the rate of evolution, and the amount of hydrogen evolved are presented.

11564. Wall, L. A., Flynn, J. H., Straus, S., **Rates of molecular vaporization of organic plasticizers,** *Polymer Eng. Sci.* **10,** No. 1, 19-23 (Jan. 1970).

Key words: Energy of vaporization; internal energies of vaporization; molecular vaporization; organic plasticizers; plasticizers; solubility parameters.

The kinetics of the molecular vaporization process of 21 plasticizers were investigated in detail. By both isothermal and nonisothermal kinetic methods, it was evident that 11 were quite pure single compounds, while 10 were clearly mixtures of compounds. For the single component species internal energies for vaporization and rates of volatilization are listed. The internal energies of vaporization are about one-half or less of values one can estimate from the additive factor method of Small. Thus, solubility parameters based on our experimental values are low by about 30 percent. From this and previous work on linear alkanes, it is concluded that in the molecular vaporization process, the large organic molecules studied evaporate approximately as spheres and hence low values for the energy of vaporization are obtained. Consequently, the difference between our experimental energy and that estimated from solubility parameters is the energy for extending the molecule in a vacuum environment.

11565. White, H. J., Jr., **Absorption of cationic surfactants by cellulosic substrates,** Chapter 9 in *Cationic Surfactants* **4,** 311-340 (Marcel Dekker, Inc., New York, N. Y., 1970).

Key words: Absorption; adsorption; cationic surfactants; cellulosic materials; review.

The physical chemistry of the interaction of cationic surfactants with cellulosic substrates is reviewed.

11566. Wilson, W. K., **Discussion of paper "New Approaches to Preservation," by Richard D. Smith,** *Library Quart.* **40,** No. 1, 171-175 (Jan. 1970).

Key words: Accelerated aging; acidity; aging; alkaline filler; aqueous deacidification; deacidification; degradation; laboratory aging; non-aqueous deacidification; pH.

A discussion of Mr. Smith's paper is followed by some remarks on the philosophy of the approach to research on the preservation of records and especially to the use of laboratory aging as a research tool.

11567. Becker, E. D., Ferretti, J. A., Farrar, T. C., **Driven equilibrium Fourier transform spectroscopy. A new method for nuclear magnetic resonance signal enhancement,** *J. Am. Chem. Soc.* **91,**7784-7785 (1969).

Key words: Driven-equilibrium; Fourier-transform; high resolution; nuclear magnetic resonance.

A new method using a high-resolution pulsed NMR spectrometer is described by which the equilibrium magnetization of nuclei with long T_1 may be restored rapidly in order to take full advantage of the Fourier transform technique.

11568. Bender, P. L., Alley, C. O., Currie, D. G., Dicke, R. J., Faller, J. B., **Some implications for physics and geophysics of laser range measurements from earth to a lunar retro-reflector,** (Proc. Conf. NATO Advanced Study Institute, University of Newcastle, Upon Tyne, England, Mar.-Apr. 1967), Chapter in *The Application of Modern Physics to the Earth and Planetary Interiors,* S. K. Runcorn, ed., pp. 523-530 (John Wiley and Sons Inc., London, England, 1969).

Key words: Astronomy; continental drift; geophysics; gravity; laser; lunar; moon.

The technique of high-accuracy laser range measurements to an optical retro-reflector package on the moon is discussed. The information which can be obtained by this method about the hypotheses of continental drift and ocean floor spreading and about the motion of the pole is described. A method for checking on the constancy of the gravitational constant is also given. The accuracy with which information on all of these questions can be obtained from lunar range measurements is higher than for any other methods which have been suggested.

11569. Bennett, L. H., **Comments on "Fe and Ni hyperfine fields in Ni_3Fe,"** *Phys. Rev.* **188,** No. 2, 1048 (Dec. 10, 1969).

Key words: Alloys; hyperfine fields; iron; nickel; nuclear magnetic resonance.

A model is presented to explain the observed hyperfine fields in Ni_3Fe.

11570. Berger, M. J., Seltzer, S. M., **Penetration of electrons and associated bremsstrahlung through aluminum targets,** Chapter in *Protection Against Space Radiation, NASA SP-169,* pp. 285-322 (National Aeronautics and Space Administration, Greenbelt, Maryland, 1968).

Key words: Aluminum transmission; bremsstrahlung; electrons; Monte Carlo; penetration; thick target bremsstrahlung; transport theory.

This paper contains a brief description of Monte Carlo programs designed to calculate the transport of fast electrons and associated bremsstrahlung through extended media. Two applications are discussed: (1) transmission of electrons through plane-parallel targets, and (2) emergence of secondary bremsstrahlung from such targets. It is shown that the predicted results are in reasonably good agreement with recent experiments for electron beams with energies up to 8 MeV incident normally on aluminum targets. Extensive new calculated data for transmission and thick-target bremsstrahlung production are presented for aluminum targets exposed to an isotropic electron flux.

11571. Birky, M. M., **Simultaneous recording of near-field and far-field patterns of lasers,** *Appl. Opt.* **8,** No. 11, 2249-2253 (Nov. 1969).

Key words: Far-field diffraction; laser; near-field diffraction; neodymium; ruby.

A technique for simultaneous recording of near-field and far-field diffraction patterns at several exposures for a single laser pulse has been developed. A ruby laser and a neodymium doped glass laser have been investigated. The Nd^{+3} laser shows striking high order cylindrical mode operation as a result of thermal stress. The time resolved output of this laser shows the usual spikes about 500 nanoseconds wide. When the cylindrical mode operation takes place some of the spikes consist of a large number of ultrashort pulses.

11572. Brady, E. L., **The National Standard Reference Data System,** *Mater. Res. Std.* **9,** No. 10, 19-21 (Oct. 1969).

Key words: Critical evaluation; information centers; information services; NSRDS; physical properties; standard reference data.

The National Standard Reference Data System is a government-wide effort to give to the technical community of the United States optimum access to the quantitative data of physical science, critically evaluated and compiled for convenience. This program was established in 1963 by the President's Office of Science and Technology, acting upon the recommendation of The Federal Council for Science and Technology. The NBS has been assigned responsibility for administering the effort. The general objective of the NSRDS is 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. The NSRDS is conducted as a decentralized operation of nation-wide scope with central coordination by NBS. It comprises a complex of data centers and other activities carried on in government agencies, academic institutions and non-governmental laboratories. The independent operational status of existing critical data projects is maintained and encouraged. Data centers that are components of NSRDS produce compilations of critically evaluated data, critical reviews of the state of quantitative knowledge in specialized areas and computations of useful functions derived from standard reference data.

11573. Christ, B. W., **On the mechanism of interstitial-impurity-induced cross-slip in iron deformed near 175 K,** *Acta Met.* **17,** No. 10, 1317-1321 (Oct. 1969).

Key words: Cross-slip; ductility; interstitial impurity; iron; nitrogen; yield stress.

A mechanism is proposed whereby the elastic dipole distortion of stationary interstitial impurity atoms in lattice solution can promote nucleation and stabilization of double-kink-size dislocation segments on cross-slip planes. Stress relaxation accompanying interstitial-impurity-induced cross-slip can account for the experimental observations that small atom fractions of nitrogen in lattice solution in iron deformed around 175 K decrease yield and flow stresses and increase ductility.

11574. Christ, B. W., Gamble, R. P., Smith, G. V., **On the distinction between alloy softening due to nitrogen and nickel in dilute lattice solution in iron,** *Script. Met.* **3,** No. 8, 521-530 (Aug. 1969).

Key words: Alloy softening; elastic; electronic; Fe-N alloys; Fe-Ni alloys; flow stress; lower yield stress; mobile dislocation density; Peierls stress.

Alloy softening (AS) is the decrease in yield and flow stresses of iron and other b.c.c. metals which accompanies increasing quantities of solute in lattice solution, within critical ranges of solute concentration and temperature. This note is a comparison of existing alloy softening data on Fe-N and Fe-Ni. Whereas AS in each alloy system is due to a reduction in the thermal component of stress, the basic cause of the reduction is different in each system. This is inferred from differences in the concentration and temperature dependence of AS for each alloy system. AS in Fe-N is attributed to an increase in mobile dislocation density during yielding and flow, as compared with that of hydrogen-purified iron, arising from the mechanism of interstitial-impurity-induced cross-slip. AS in Fe-Ni is attributed to a systematic reduction in the Peierls stress of iron with increasing Ni. Whereas AS in Fe-N is primarily of elastic origin, AS in Fe-Ni is primarily of electronic origin.

11575. Cohen, M. I., Casella, R. C., Blunt, R. F., Forman, R. A., **Lattice absorption in strontium titanate,** *Phys. Rev.* **186,** No. 3, 834-838 (Oct. 15, 1969).

Key words: Brillouin zone; critical points; infrared; optical absorption; phonons; selection rules; strontium titanate.

The optical absorption spectrum of $SrTiO_3$ is presented over the energy range 0.05 eV to 0.3 eV, well below the fundamental edge. Nine absorption bands are observed. We interpret all but one of them as being due to multi-phonon creation processes. The sole exception is a band at 0.068 eV which we attribute to a single-phonon process. Selection rules for simultaneous creation of either two or three phonons are obtained in dipole approximation, at selected critical points in the Brillouin zone. The observed bands are assigned using these rules together with the experimental phonon dispersion curves of Cowley and other published values for the higher energy branches obtained at specific points in the zone by other techniques.

11576. Currie, L. A., **Indirect estimation of component variability in chemical and physical systems,** *Anal. Chem.* **41,** No. 14, 2051-2054 (Dec. 1969).

Key words: Chemical microstandards; correlation coefficient; indirect variability estimation; stoichiometry; two-component system.

An indirect method is presented for assessing the variability of a chemical component or a physical property, when that property may not be directly observed. The method is based upon a simple physical model incorporating stoichiometry and the observation of the variability of a second, related property and/or the ratio of the two properties. A principal result of the investigation is an expression giving limits for the relative standard deviation of component-A, ϕ_A: $|\phi_{A/B}^2 - \phi_B^2| \leqslant \phi_A^2 \leqslant \phi_{A/B}^2 + \phi_B^2$ where $\phi_{A/B}$ and ϕ_B represent the relative standard deviations of the ratio of components -A and -B and of component-B, respectively. Information is also obtained on bounds for the correlation coefficient.

11577. Durst, R. A., **Fluoride microelectrode—fabrication and characteristics,** *Anal. Chem.* **41,** No. 14, 2089-2090 (Dec. 1969).

Key words: Fluoride analysis; fluoride microanalysis; fluoride microelectrode; ion-selective microelectrode; microelectrode; potentiometry.

A fluoride ion-selective microelectrode has been constructed with a volume requirement of less than 2 μl. This microelectrode has the advantage of being suitable for *in situ, in vivo,* and continuous analysis of microliter volumes of solution. Details of construction and the response characteristics are given. Nernstian response is observed down to less than 10-5*M* fluoride. Further miniaturization is feasible by extension and refinement of this design.

11578. Ederer, D. L., **Computer analysis of resonance profiles by the method of least squares,** *Appl. Opt.* **8,** No. 11, 2315-2325 (Nov. 1969).

Key words: Beutler-Fano resonance profiles; least squares analysis; parameter correlation; random errors; slit function; slit width-resonance width ratio; systematic errors.

The method of least squares has been applied to the analysis of resonance profiles described by the Beutler-Fano (BF) absorption cross-section. To illustrate the method, parameters were determined for experimental data having BF profiles of (a) the asymmetric, enhanced absorption type, (b) the "window" type, and (c) the Lorentzian absorption type. Systematic and random errors, and correlation among the parameters were studied as a function of the slit width to resonance width ratio by applying the least squares fitting method to data computed by folding the BF transmission profile with a gaussian slit function. High correlation among the parameters and parameter fractional standard deviations of 10% to 20% for data with a standard deviation of 0.01 are an incentive to keep the slit width to resonance width ratio less than two for "window" type resonances. In addition it was found that the parameters describing a resonance could be determined with the greatest precision in a given time when the slit width to resonance width ratio was of order one. It was found that systematic errors greater than about one percent resulted if the number of mesh points used to approximate the convolution integral in the fitting procedure was less than at least two per resonance width. Also, for resonances whose width was equal to the slit width, systematic errors in the parameter values of order ten percent resulted if the width of slit function used in the fitting procedure differed from the "actual" slit function by ten percent.

11579. Eick, J. D., Caul, H. J., Hegdahl, T., Dickson, G., **Chemical composition of dental gold casting alloy and dental wrought gold alloys,** *J. Dental Res.* **48,** No. 6, 1284-1289 (Nov.-Dec. 1969).

Key words: Casting gold alloys; chemical composition; dental gold alloys; gold; plantinum; wrought gold wire; x-ray emission.

The chemical composition of 136 dental casting gold alloys and 21 dental wrought gold wire alloys was determined by an x-ray emission method. The changes in composition from 1928 and 1932 to the present time are small. There has been a decrease in platinum content in both castings and wires. About 1% nickel is found in the present-day wire which was not present in 1928 and 1932.

11580. Fatiadi, A. J., **Preparation of inositol hexasulfate,** *Carbohydrate Res.* **12,** 293-296 (1970).

Key words: Acid; chlorosulfonic; fuming; hexapotassium; hexasulfate; salt; sulfuric.

Inositol hexasulfate has been prepared in 55-62% yield by direct interaction of *myo*-inositol with either fuming sulfuric acid or chlorosulfonic acid at 60-75 °C. The hexasulfate was isolated from the reaction mixture by an exchange reaction with potassium chromate or by direct neutralization with potassium hydroxide; the inositol hexasulfate hexapotassium salt crystallizes out first ("salting out").

11581. Feldman, A., Horowitz, D., **Refractive index of cuprous chloride,** *J. Opt. Soc. Am.* **59,** No. 11, 1406-1408 (Nov. 1969).

Key words: CuCl; dispersion; interference fringes; refractive index; refractometer.

The refractive index of single crystal CuCl was measured in the wavelength range 0.42 μm to 22 μm using a commercial V-block refractometer and also by measuring the wavelength dependence of interference fringes in thin polished plates.

11582. Frederikse, H. P. R., **Superconducting semiconductors,** (Proc. Conf. International Advanced Study Institute: Electronic Structures in Solids, Chania, Crete, Greece, June 30-July 14, 1968), Chapter in *Electronic Structures in Solids,* pp. 270-282 (Plenum Press Inc., New York, N. Y., 1969).

Key words: Semiconductors; solid state; strontium titanate; superconducting semiconductors.

The application of the BCS theory to multi-valley semiconductors as carried out by M. L. Cohen is described. The optimum conditions for finding superconductivity in semiconductors are listed. Application of these ideas to $SrTiO_3$ and the experiments concerned with superconductivity in this compound are discussed. Other examples are mentioned.

11583. Haber, S., **Stochastic quadrature formulas,** *Math. Computation* **23,** No. 108, 751-764 (Oct. 1969).

Key words: Degree of precision; Hadamard matrices; integration; Monte Carlo; multiple integrals; numerical integration; numerical methods; quadrature; random.

A class of formulas for the numerical evaluation of multiple integrals is described, which combines features of the Monte Carlo and the classical methods. For certain classes of functions—defined by smoothness conditions—these formulas provide the fastest possible rate of convergence to the integral. Asymptotic error estimates are derived, and a method is described for obtaining good *a posteriori* error bounds when using these formulas. Equal-coefficients formulas of this class, of degrees up to 3, are constructed.

11584. Haber, S., Osgood, C. F., **On the sum $\Sigma \langle n\alpha \rangle^{-t}$ and numerical integration,** *Pacific J. Math.* **31,** No. 2, 383-394 (1969).

Key words: Continued fraction; diophantine approximation; integration; multiple integration; number theory; numerical analysis; numerical integration; periodic (functions); quadrature.

It is shown that a certain problem in Diophantine Approximation—the estimation of sums of the form $\sum_{n=k}^{AK} \langle n\alpha \rangle^{-t}$, where α is an irrational number, "$\langle\ x\ \rangle$" denotes the distance from x to the nearest integer, and A is a fixed number greater than 1—is related to the estimation of the error in Korobov's method of numerical integration of periodic functions of several real variables. Some estimates of such sums are found, for certain classes of irrational numbers.

11585. Haller, W., Blackburn, D. H., Wagstaff, F. E., Charles, R. J., **Metastable immiscibility surface in the system Na_2O-B_2O_3-SiO_2,** *J. Am. Ceram. Soc.* **53,** No. 1, 34-39 (1970).

Key words: B_2O_3-Na_2O-SiO_2; glass; immiscibility; melts; microheterogeneities; Na_2O-B_2O_3-SiO_2; SiO_2-B_2O_3-Na_2O.

Opalescence and clearing techniques have been used to determine the metastable immiscibility surface for sodium borosilicate solutions. These results indicate that a three-liquid region, which may or may not be metastable to two-liquid regions, underlies the immiscibility surface.

11586. Heinrich, K. F. J., **Advances in the metallurgical application of electron probe microanalysis,** *Proc. Conf. 5th International Congress on X-ray Optics and Microanalysis, Tubingen, Germany, Sept. 9-14, 1968,* G. Mollebstedt and K. H. Gaukler, eds., pp. 415-423 (Springer-Verlag Publ. Co., Berlin, Germany, Dec. 1969).

Key words: Applications; electron probe; microanalysis; metallurgy; spectrometry; x-rays.

Electron probe microanalysis is widely used in the investigation of phenomena of general metallurgical interest as well as in the study of specific materials and processes. New devices for x-ray detection, and automatic data collection, increase the usefulness of the microprobe for such applications. Besides the well-known methods for qualitative and quantitative electron probe analysis, the instrument can also be used advantageously for quantitative metallography and related techniques.

11587. Heinrich, K. F. J., Yakowitz, H., **Propagation of errors in correction models for quantitative electron probe microanalysis,** *Proc. Conf. 5th International Congress on X-ray Optics and Microanalysis, Tubingen, Germany, Sept. 9-14, 1968,* G. Mollebstedt and K. H. Gaukler, eds., pp. 151-159 (Springer-Verlag Publ. Co., Berlin, Germany, Dec. 1969).

Key words: Absorption of x-rays; atomic number effects; error propagation; fluorescence; microprobe analysis; quantitative analysis.

Lack of appropriate standards frequently forces the analyst to use elemental standards. The usefulness of correction models is limited by the accuracy to which the input parameters are known. Uncertainties in presumably known quantities (mass absorption, coefficients, fluorescence yield, mean ionization potentials, etc.) are in many cases the limiting factors. The resulting analytical errors can be minimized by judicious choice of experimental conditions. This paper will give examples involving the corrections for absorption, fluorescence by characteristic lines, and atomic number effects.

11588. Henderson, B., Stokowski, S. E., Ensign, T. C., **Luminescence from F centers in calcium oxide,** *Phys. Rev.* **183,** No. 3, 826-831 (July 15, 1969).

Key words: Calcium oxide; color centres; F-centres; luminescence; optical absorption; radiative lifetimes.

This paper reports data on the luminescence spectra associated with F^- and F^+-centres in calcium oxide. Irradation in the F-band excites emission bands at 500 nm and 627 nm, which we identify with the transitions $^1P \rightarrow {}^1S$ and $^3P \rightarrow {}^1S$ respectively of the F-centre. Radiative lifetime measurements are consistent with this assignment. It is suggested that the weakness of the 500 nm band relative to the 627 nm band is due to competition between the $^1P \rightarrow {}^1S$ transition and a radiationless decay from the $^1P \rightarrow {}^3P$-level. At 4 K well-resolved fine structure is observed on the high energy side of both the 627.0 nm band and the 369.7 nm (F^+-band) band. For both bands the phonon assisted structure can be reconstructed using only three vibrational modes.

11589. Hosler, W. R., Frederikse, H. P. R., **Magnetoresistive effects in $KTaO_3$,** *Solid State Commun.* 7, 1443-1449 (1969).

Key words: Band structure; magnetoresistance; perovskites; potassium tantalate.

The magnetoresistance of semiconducting $KTaO_3$ has been investigated. Low field results indicate that the bottom of the conduction band consists of 3 or 6 ellipsoids along the $\langle 100 \rangle$ crystalline axes, similar to the energy band model predicted (and experimentally confirmed) for $SrTiO_3$. Contrary to expectations the high field magnetoresistance did *not* show Shubnikov-de Haas oscillations.

11590. Kieffer, L. J., **Low-energy electron-collision cross-section data. Part I: Ionization, dissociation, vibrational excitation,** *Atomic Data* **1,** 19-89 (1969).

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

Graphical displays of selected experimental data on cross sections as functions of electron energy are presented for some 60 targets important in aeronomy, astrophysics, and plasma physics. The processes covered are ionization, dissociation, and vibrational excitation. Criteria for data selection are discussed. The literature available up to September, 1968, has been searched.

11591. Klose, J. Z., **Transition probabilities and mean lives of the $3s_2$ laser level in neon I,** *Phys. Rev.* **188,** No. 1, 45-49 (Dec. 5, 1969).

Key words: Atomic lifetimes; atomic spectra; atomic transition probabilities; laser; neon.

The mean life of the $3s_2$ (Paschen notation) laser level in Ne I has been measured for a series of pressures in the range of 3 to 11 μm of Hg using a method of delayed coincidence. The lifetime values, obtained by means of the $3s_2 \rightarrow 2p_4$ (6328 Å) transition, show an increase in magnitude with increasing pressure. This pressure dependence was interpreted as being due to the imprisonment of the 600.04 Å spectral line emitted in the transition of the $3s_2$ level to the ground state. The Holstein theory of the imprisonment of resonance radiation was applied to the analysis of the lifetime vs pressure data to yield the following results: $A_{600} = 1.8 \pm 0.5 \times 10^7 \text{ sec}^{-1}$, $\Sigma' A = (\Sigma A - A_{600}) = 1.76 \pm 0.10 \times 10^7 \text{ sec}^{-1}$, and lifetimes of 28 ± 4 and 57 ± 3 nanoseconds for the low-pressure and high-pressure limits respectively. The error limits are obtained from the maximum estimated errors in the measured lifetimes and the measured pressures. Experimental results of other workers along with theoretical values calculated under various assumptions are presented for comparison with the results of the present work.

11592. Kostkowski, H. J., Erminy, D. C., Hattenburg, A. T., **High-accuracy spectral radiance calibration of tungsten-strip lamps,** Chapter 4 in *Advances in Geophysics* **14,** 111-127 (Academic Press Inc., New York, N.Y., 1970).

Key words: Blackbody; high temperature measurement; radiometry; spectral radiance; standards calibrations; tungsten strip lamp.

The accuracy of calibrating tungsten strip lamps in terms of absolute spectral radiance has been significantly improved. The standard deviation uncertainty of these calibrations is estimated to vary from 0.3 percent at 850 nm to 1.5 percent at 210 nm. This accuracy has been realized as a result of: (1) The development of a highly stable 3000 K blackbody and a detailed investigation of its quality. (2) Increasing the accuracy with which the blackbody temperature could be determined. (3) Reducing and evaluating errors resulting from scattered light, polarization, and slit-function effects. Highlights of the instrumentation, the temperature measurement and the various error investigations are presented.

11593. Lang, S. B., Rice, L. H., Shaw, S. A., **Pyroelectric effect in barium titanate ceramic,** *J. Appl. Phys.* **40,** No. 11, 4335-4340 (Oct. 1969).

Key words: Barium titanate; ceramics; ferroelectricity; phase transitions; pyroelectricity; spontaneous polarization.

The pyroelectric coefficient (at constant stress) of a 95 percent $BaTiO_3$, 5 percent $CaTiO_3$ ceramic composition (Clevite Ceramic B) was measured over the temperature range from 4.9 to 400 K. Extrema in the pyroelectric coefficient were observed at the rhombohedral-orthorhombic transition point (150 to 170 K), the orthorhombic-tetragonal transition point (240 to 260 K), and the tetragonal-cubic transition point (Curie point, at 387 K). The pyroelectric coefficient showed no anomalous behavior below 150 K. A spontaneous polarization curve derived from the pyroelectric results is compared with published single-crystal measurements. A model for ceramic polarization suggests that domain switching at phase transitions is biased by electrical interactions arising from space charges and by mechanical interactions resulting from internal strains.

11594. McAlister, A. J., **Calculation of the soft x-ray K-emission and absorption spectra of metallic Li,** *Phys. Rev.* **186,** No. 3, 595-599 (Oct. 15, 1969).

Key words: Absorption spectrum; band calculation; emission spectrum; K-spectra; lithium; transition probability.

In an attempt to account for the premature peaking of the Li K-emission spectrum, detailed augmented plane wave calculations were performed for metallic Li, at many general points in the Brillouin zone as well as symmetry points. Wave functions were extracted, and the one electron K-emission and absorption transition densities evaluated. The screening arguments so commonly invoked were not employed. No early peaking was found in the emission density. Various spectral broadening mechanisms were assessed. A good fit to the experimental data was obtained by including available estimates of K-state broadening by the phonon field. At present, there is no basis for claiming uniqueness for this agreement.

11595. Manning, J. R., **Cross terms in the thermodynamic diffusion equations for multicomponent alloys,** *Met. Trans. AIME* **1,** 499-505 (Feb. 1970).

Key words: Alloys; cross terms; diffusion; multicomponent alloys; random alloys; thermodynamic equations.

The kinetic equations for the atom fluxes in a multicomponent alloy are derived in terms of atomic driving forces for a random alloy model. In this model, the contribution of each atom flux from the vacancy wind effect is directly proportional to the vacancy flux. The kinetic equations allow the L_{ik} coefficients to be identified. The cross terms relating the flux of species i to the chemical potential gradients of other species k are found to be non-zero. Neglecting the cross terms can lead to serious inaccuracies since these terms can have an appreciable effect on the atom fluxes and can lead to negative intrinsic diffusion coefficients even in ideal systems. The L_{ik} in an n-component system depends on the n tracer diffusion coefficients. In this respect, it still is possible to express the n atom fluxes in terms of only n coefficients.

11596. Meyerson, M. R., Friedman, L., Giles, P. M., **Dimensional stability of 12 nickel maraging steel at ambient temperatures,** *Trans. ASM* **62,** No. 3, 809-812 (Sept. 1969).

Key words: Gage blocks; maraging steel; nitriding; precision equipment; surface hardened; temporal dimensional stability; ultrastability.

The maraging steels attain high strength with a relatively simple low temperature heat treatment. The nature of the heat treatment and the low carbon content of the steels indicated low residual stress levels, small lattice distortions, nitridability and other characteristics which are known to promote dimensional stability at high strength levels. A 12% nickel maraging steel was treated to produce a surface hardness of greater than R_c 65 and its dimensional stability at submicroinch levels was observed over a period of about 2 1/2 years. The steel as treated was found to be ultrastable, with an average decrease in length of only 0.05 to 0.10 micrometers per meter per year. Its performance meets or exceeds that of any of the many other materials previously investigated at NBS.

11597. Mosburg, E. R., **Periodic potential probe configuration for plasma diagnostics,** *J. Appl. Phys.* **40,** No. 13, 5290-5300 (Dec. 1969).

Key words: Diffuse flux; plasma diagnostics; plasma probes.

A probe having a spacially periodic potential is created by a bifilar winding of small tungsten wire. This geometry results in an electric field configuration having an extremely short penetration distance into the plasma. The behavior of this probe is studied in extended negative glow and back-diffusion type plasmas. The floating mode current-voltage characteristic curve is seen to be quite different from that of the usual double probe in that no effects of the electrons are observed. The behavior of the periodic probe is controlled by the ion inertia established in the diffusion region which lies just in front of the probe. The important parameter of the characteristic curve is the slope near zero applied voltage difference. This slope can be related in a simple manner to the flux of plasma diffusing to the probe and to the diffusion drift energy of the ions as they reach the probe. The electrons make no contribution to this slope for low applied voltage differences. This probe thus provides a very sensitive method for measuring the diffusive flux of plasma to a containing wall.

11598. Mozer, B., Price, D. L., Keating, D. T., Meister, H., **Incoherent neutron scattering from liquid and solid CuNi,** *Physics Letters* **30A,** No. 3, 206-207 (Oct. 6, 1969).

Key words: Alloy; CuNi; incoherent; liquid; neutron; scattering; solid.

Incoherent inelastic neutron scattering measurements were performed on $Cu_{.525}\ Ni^{62}_{.475}$ alloy in the liquid and solid state. The excitation spectrum is strikingly similar between liquid and solid. The diffusion coefficient (4×10^{-5} cm^2/sec.) in the liquid was determined from the broadened elastic peak.

11599. Newman, M., **Isometric circles of congruence groups,** *Am. J. Math.* **XCI,** No. 3, 648-656 (July 1969).

Key words: Diophantine approximation; modular groups.

Let n be any positive integer, ϵ any positive number. The principal result of this paper is that the fundamental region of the principal congruence subgroup $\Gamma(n)$ of the modular group Γ consists of circles of radii $1/r$, where $r = O(n^{2+\epsilon})$.

11600. Ohashi, M., Paffenbarger, G. C., **Some flow characteristics at 37 °C of ternary wax mixtures that may have possible dental uses,** *J. Nihon University Dentistry* **11,** No. 3, 109-208 (Sept. 1969).

Key words: Dental; flow; wax.

One hundred and eighty two ternary diagrams of the flow at 37 °C of mixtures of commercial waxes indicate some of these mixtures may have dental use.

11601. Paabo, M., Bates, R. G., **Deuterium isotope effects and the dissociation of deuteriophosphoric acid from 5 to 50°,** *J. Phys. Chem.* **74,** No. 4, 706-710 (Feb. 19, 1970).

Key words: Acidity; deuteriophosphoric acid; deuterium oxide; dissociation constant; Emf measurements; isotope effects; phosphoric acid; pK; thermodynamics.

The first dissociation constant of deuteriophosphoric acid in deuterium oxide has been determined over the temperature range 5 to 50 °C from emf measurements of cells using deuterium gas electrodes and silver-silver chloride electrodes, with the following results: $pK_1 = 843.979/T - 4.5714 + 0.0139555T$, where T is the thermodynamic temperature. The changes of enthalpy, entropy, and heat capacity characterizing the dissociation process have been derived from pK_1 and its temperature coefficient. By comparison of the results with similar data for protiophosphoric acid in water, the deuterium isotope effects on pK_1 and the thermodynamic functions have been evaluated. The isotope effect pK_1(in D_2O)-pK_1(in H_2O) is 0.272 unit and almost unchanged over the temperature range studied. This value confirms a linear relationship between the isotope effect for inorganic acids and pK(in H_2O).

11602. Paabo, M., Bates, R. G., **Dissociation constant of protonated 2,2-bis(hydroxymethyl)-2,2′,2″-nitrilotriethanol (bis-tris) and related thermodynamic functions from 0 to 50°,** *J. Phys. Chem.* **74,** No. 4, 702-705 (Feb. 19, 1970).

Key words: Acidity; bis-tris; buffer solutions; dissociation constant; ionization constant; pH; pK; thermodynamics; 2,2-bis(hydroxymethyl)-2,2′2″-nitrilotriethanol.

The acidic dissociation constant of protonated 2,2-bis(hydroxymethyl.-2,2′2″-nitrilotriethanol ("bis-tris") has been determined at 11 temperatures from 0 to 50 °C by emf measurements of hydrogen-silver chloride cells without liquid junction. At 25 °C, pK_a is 6.483, and consequently buffer solutions of the base and its hydrochloride are useful for pH control in the region pH 5.5 to 7.5. The values of pK_a over the temperature range studied are given as a function of the thermodynamic temperature (T) by the equation $pK_a = 1287.855/T + 2.7905 - 0.00210396T$. Standard thermodynamic functions for the acidic dissociation process have been derived. At 25 °C, $\Delta H^\circ = 28{,}238$ J mol^{-1}, $\Delta S^\circ = -29.4$ J K^{-1} mol^{-1}, and $\Delta C_p^\circ = 24$ J K^{-1} mol^{-1}. Conventional pa_H values for five equimolal buffer solutions composed of bis-tris and its hydrochloride have been calculated.

11603. Sieck, L. W., Searles, S. K., Ausloos, P., **High-pressure photoionization mass spectrometry. I. Unimolecular and bimolecular reactions of $C_4H_8^+$ from cyclobutane,** *J. Am. Chem. Soc.* **91,** No. 27, 7627-7634 (Dec. 31, 1969).

Key words: Cyclobutane; ion-molecule reactions; mass spectrometry; photoionization; reaction kinetics; vapor phase.

Various mixtures of cyclobutane with cyclohexane, methylcyclopentane, 2-methylpentane, and cyclopentane have been selectively photolyzed at either 1236 Å (10.0 eV) or 1165 Å (10.6 eV) in a mass spectrometer designed to provide specific information concerning thermal ion-molecule reactions occurring in the gas phase. The modes of reaction, as well as the total reactivity found for $C_4H_8^+$ from cyclobutane in mixtures with the various hydrocarbons have been compared with those determined for 1-$C_4H_8^+$ and 2-$C_4H_8^+$ ions produced by photoionization of the appropriate butene at 10.0 eV. Evaluation of these data, including the charge exchange pattern for $C_4H_8^+$ established by the addition of compounds with various ionization potentials (NO, trimethylamine, cyclohexane, etc.), indicate that the $C_4H_8^+$ ion from cyclobutane is non-cyclic and that the probability for isomerization to a 1-$C_4H_8^+$ ion structure is approximately 0.2. The reaction cyclo-$C_6H_{12}^+ + \square \rightarrow C_6H_{12} + C_4H_8^+$, where cyclo-$C_6H_{12}^+$ is produced by photoionization of cyclohexane at 10.0 eV, has also been found. The interesting feature of this process is that charge exchange is exothermic only if $C_4H_8^+$ acquires a butene ion structure during the lifetime of the collision complex.

11604. Skolnik, H., Tauber, S. J., **Introduction to the symposium on management and operation of information groups and centers,** *J. Chem. Doc.* **9,** No. 4, 195 (Nov. 1969).

Key words: Classification; data; distribution symposium; documents; evaluation; information systems; management; operation.

This paper serves to introduce a set of papers with the following titles: Literature Searching Activities in a Technical Information Center; Operation of duPont's Patent Index; Information Operations at Esso Research Engineering Company; The Management of Information Operations at Lederle Laboratories; Management of Operations and Services in the Hercules Technical Information Division; Some Administrative Considerations at Biosciences Information Services; Technical Information Management in the U.S. Patent Office; The Role of a Government Agency as Coordinator of a Large Information System; The Transfer of Security Classified Information; Clearinghouse Announcements; The Reliability of Property Data, or Whose Guess Shall We Use?; Development and Application of Selection Criteria for Computer Systems; Organization and Management of Smith, Kline & French's R & D Information Facility.

11605. Utech, H. P., **Growing crystals in space,** *Proc. Conf. Manufacturing Technology Unique to Zero Gravity Environment, George C. Marshall Space Flight Center, Nov. 1, 1968, Huntsville, Alabama,* pp. 197-214 (National Aeronautics and Space Administration, Greenbelt, Md., 1969).

Key words: Crystal growing; crystals; gravity; metal; space.

11606. Weiss, A. W., **Superposition of configurations and atomic oscillator strengths—boron isoelectronic sequence,** *Phys. Rev.* **188,** No. 1, 119-130 (Dec. 5, 1969).

Key words: Energy levels; oscillator strengths; superposition of configurations; wave functions.

Oscillator strengths have been computed for transitions between a number of low-lying levels in B I and Ne VI. The wavefunctions were computed by the method of superposition of configurations, utilizing the pseudonatural orbital technique to accelerate convergence. The asymptotic, large-Z limiting f-values were also computed, using the nuclear charge perturbation expansion. Together with previous theoretical data from C II, these results have been used to make a graphical study of the f-value behavior for these transitions along the isoelectronic sequence. Comparisons were made between experiment and the predictions of the Hartree-Fock and charge expansion methods as well as the present calculations. Finally these theoretical curves were used to predict individual f-values for each member of the sequence through $Z = 15$ (P XI).

11607. Wiederhorn, S. M., Moses, R. L., Bean, B. L., **Plastic deformation and the fracture surface energy of sodium chloride,** *J. Am. Ceram. Soc.* **53,** No. 1, 18-23 (Jan. 21, 1970).

Key words: Cleavage; fracture; fracture energy; plastic deformation; sodium chloride; surface energy.

This paper presents a correlation between plastic deformation at crack tips in sodium chloride and the measured value of the fracture surface energy. It is shown that plastic deformation can either aid or hinder crack growth depending on the mode of deformation at the crack tip. If plane stress deformation occurs, crack motion is hindered by step formation, dislocation generation and plastic blunting of the crack tip. If plane strain deformation occurs, crack motion is aided by stress fields that arise from the deformation. The specific surface free energy of sodium chloride, {100} plane, is estimated to lie between 0.3 and 0.37 J/m^2.

11608. Young, K. F., Frederikse, H. P. R., **Temperature and pressure dependence of dielectric constant of cadmium fluoride,** *J. Appl. Phys.* **40,** No. 8, 3115-3118 (July 1969).

Key words: Cadmium fluoride; dielectric constant; pressure dependence; temperature dependence.

The temperature and pressure dependence of the dielectric constant ϵ' of CdF_2 has been measured for $T = 4\text{-}300$ K (at atmospheric pressure) and $P = 1\text{-}2000$ bar (at room temperature). The frequency dependence of the real and imaginary part (ϵ' and ϵ'') has been investigated up to 100 MHz.

11609. Ballard, D. B., Yakowitz, H., **Investigation of secondary cracks from the failed Point Pleasant, West Virginia bridge,** *Proc. Third Annual Scanning Electron Microscope Symp., April 1970,* pp. 321-328 (Illinois Institute of Technology, Research Institute, Chicago, Ill., 1970).

Key words: Electron probe microanalysis; ion microanalysis; metallography; nondispersive x-ray analysis; Point Pleasant, W. Va. bridge; scanning electron microscopy.

Secondary cracks in an eyebar of the Point Pleasant, West Virginia bridge were investigated by means of scanning electron microscopy, electron probe microanalysis, and optical metallographic techniques. The observed microstructure, surface topography, and sulfur gradient in the secondary cracks suggest the mechanism of stress corrosion as the cause for crack propagation.

11610. Blake, R. W., **Language of performance, an NBS project,** *Mater. Res. Std.* **9,** No. 3, 11-14 (Mar. 1969).

Key words: Performance language; performance specifications; performance type tests; test development.

The Public Buildings Service, National Bureau of Standards Building Systems Project is an experimental effort to affect a procurement on a performance basis of one million square feet of a building system for use in new construction of government office buildings. The building system proposed is a Floor-Ceiling Sandwich (FTS) and Space Divider System consisting of the floor, the ceiling below, the luminaires (lighting fixtures) in the ceiling and all components between the floor and ceiling planes. The basis of procurement is a description of performance required, with the low bidder in terms of cost, being declared the winning bidder. The description of performance, i.e. the language of performance is stated as *requirement, criteria,* and *test,* all without regard to material that might be employed. Lack of testing related to usage of the building by actual users is pointed out as a limitation on the future development of performance specifications.

11611. Brenner, A., Sligh, J. L., **Electrodeless electrolysis,** *J. Electrochem. Soc.* **117,** No. 5, 602-608 (May 1970).

Key words: Electrodeless electrolysis; electrolysis; electrolysis of glass; electron beam electrolysis; fused salts; glow discharge.

Solid ionic conductors and fused salts were electrolyzed without contact of solid electrical leads. The current was carried to the materials to be electrolyzed either by means of electrons emitted by a hot filament or by a glow discharge. The materials were made the separating wall between the anode and cathode compartments of an apparatus constructed of glass or fused silica. Electrolysis of glass produced a white opaque material which did not seem to differ chemically from the original glass. Dendrites of several metals were obtained in the glow discharge electrolysis of fused salts. The results of the latter process resembled conventional electrolysis with metal electrodes and was not similar to the glow discharge electrolysis of aqueous electrolytes.

11612. Bullough, R., Simmons, J. A., **On the deformation of an imperfect solid,** Chapter 5 in *Physics of Strength and Plasticity*, A. S. Argon, ed., pp. 47-63 (Massachusetts Institute of Technology Press, Cambridge, Mass., 1969).

Key words: Continuity equations; continuous distribution of dislocations; defect measures; deformations of connections; deformations of tensors; dislocations; imperfect continuum; nonlinear elasticity; nonlinear strain measures; point defects.

A new formalism is presented for treating the nonlinear aspects of the elastic theory of continuous distributions of dislocations and point defects. The concept of deformations of tensors and connections associated with an imperfect continuum is introduced and used to obtain relevant geometric field equations together with expressions for the change of defect content without invoking either "non-Euclidean spaces or anholonomic coordinates." Attention is drawn to the fact that the ordinarily used Cauchy strain is a generally invalid strain measure and the theory is therefore developed using both the correct Green strain and other appropriate strain measures. The correct defect measure is the Cauchy torsion tensor shown to be, in general, independent of the analogous Green torsion tensor which occurs in the geometric field equation for the Green strain. The consequent difficulties are discussed and procedures for solving two new types of nonlinear defect problems are given.

11613. Caswell, R. S., Danos, M., **On the accuracy of the adiabatic separation method,** *J. Math. Phys.* **11,** No. 2, 349-354 (Feb. 1970).

Key words: Adiabatic approximation; adiabatic separation method; coupled oscillators; matrix diagonalization; nuclear collective model.

Numerical experiments performed for a model of two strongly coupled oscillators indicate that the adiabatic separation method yields accurate results even where the condition of adiabaticity is violated to a very high degree, except in those cases where two levels are degenerate in the adiabatic approximation. An accurate solution for those cases can be obtained by diagonalizing the 2×2 Hamiltonian submatrix built on the two degenerate adiabatic states. It is conjectured that the adiabatic separation method can be expected quite generally to yield highly accurate results, at least for states belonging to the discrete spectrum.

11614. Colwell, J. H., Mangum, B. W., Thornton, D. D., Wright, J. C., Moos, H. W., **Low-temperature magnetic properties of DyPO$_4$: An ideal three-dimensional Ising antiferromagnet,** *Phys. Rev. Letters* **23,** No. 21, 1245-1247 (Nov. 24, 1969).

Key words: Antiferromagnet; DyPO$_4$; exchange interaction; Ising; magnetic; three-dimensional Ising antiferromagnetic.

We have measured the magnetic susceptibility and heat capacity of DyPO$_4$ at low temperatures and compared our results with the exact series expansions based on the three dimensional Ising model for the diamond lattice. There is excellent agreement between experiment and theory.

11615. Coxon, B., **The synthesis, equilibration, and conformation of diastereoisomeric 1,2-*O*-isopropylidene-3,5-*O*-(methoxymethylidene)-6-*O*-*p*-tolylsulfonyl-α-D-glucofuranoses. Conformational evidence from a nuclear Overhauser effect,** *Carbohydrate Res.* **12,** 313-334 (May 15, 1970).

Key words: Conformations; equilibration; glucofuranoses; interaction energies; NMR spectroscopy; nuclear Overhauser effect.

The diastereoisomers of 1,2-*O*-isopropylidene-3,5-*O*-(methoxymethylidene)-6-*O*-*p*-tolylsulfonyl-α-D-glucofuranose have been prepared by treatment of 1,2-*O*-isopropylidene-6-*O*-*p*-tolylsulfonyl-α-D-glucofuranose with trimethyl orthoformate in acidified *N*,*N*-dimethylformamide. Treatment of an equilibrated mixture of these diastereoisomers with acetone gave 1,2:3,5-di-*O*-isopropylidene-6-*O*-*p*-tolylsulfonyl-α-D-glucofuranose and methyl formate. Equilibration reactions of the diastereoisomers in various solvents, at various temperatures, have been studied quantitatively by n.m.r. spectroscopy. The resulting thermodynamic data allow a decision as to the diastereoisomer that is stabilized by intramolecular dipole-dipole interactions, which, when used in conjunction with conformational evidence from vicinal coupling-constants obtained by a computed-spectrum analysis indicated the configuration of the new asymmetric carbon atom. The configurational assignments made for these diastereoisomers were supported by chemical-shift data and by the observation of a spin-coupling over five bonds. Evidence for a favored orientation of the methoxyl group in one of the diastereoisomers was obtained from nuclear Overhauser experiments in which a 25% enhancement of the signal intensity of the neighboring methylidene proton was observed. Van der Waals interaction energies have been calculated for the conformations assigned to the diastereoisomers and for the possible conformations of the closely related 1,2:3,5-di-*O*-benzylidene-α-D-glucofuranose derivatives. The nonbonded interactions in these conformations are discussed and compared.

11616. Coyle, T. D., **Silica,** *Kirk-Othmer Encyclopedia of Chemical Technology* **18,** 2nd Edition, 46-61 (1969).

Key words: Silica; silicon dioxide.

An introduction is given to the properties of silicon dioxide, including aspects of structure and bonding, the forms of silica and their interconversions, and the chemical properties and reactions of the material.

11617. Cuthill, J. R., **A soft x-ray spectrometer with improved drive,** *Rev. Sci. Instr.* **41,** No. 3, 422-423 (Mar. 1970).

Key words: Lubrication in vacuum; soft x-ray spectrometer; spectrometer drive.

The spectrometer described is a grazing incidence grating instrument with an improved drive system for moving the electronic detector around the Rowland circle. In this system the lead screw driving the detector always lies along a chord of the Rowland circle joining the grating and the detector. With this design there is less chance of error due to flexure of the components than in previous designs, and the resolution of the spectrometer is constant in wavelength.

11618. Eisenhart, C., **Anniversaries in 1970 of interest to statisticians,** *Am. Stat.* **24,** No. 1, 25-68 (Feb. 1970).

Key words: Abraham De Moivre; Avogadro's number; Brownian motion; Chauvenet's criterion; Coast and Geodetic Survey; Corrado Gini; Emile Borel; factorial moments; Ferdinand Rudolph Hassler; history of probability; Isaac Todhunter; Jean Perrin; Louis Bachelier; method of least squares; *Metron*; moments; Norbert Wiener; Office of Weights and Measures; path-space measure; Pierre Simon de Laplace; rejection of observations; Stirling's formula; Stirling's numbers; *Théorie analytique des probabilités*; William Chauvenet.

Brief recognition is given to bicentennials of the death of James Stirling (1692-1770) and birth of Ferdinand Rudolph Hassler (1770-1843); to sesquicentennials of the publication of the 3rd definitive edition of Laplace's *Théorie analytique des probabilités*, and of the births of William Chauvenet (1820-1870) and Isaac Todhunter (1820-1884); to centennials of the births of Louis Bachelier (1870-1946) and Jean Perrin (1870-1942); and to the semicentennial of the initial publication (1920) of *Metron*, an International Review of Statistics.

11619. Engen, G. F. **An evaluation of the "back-to-back" method of measuring adaptor efficiency,** *IEEE Trans. Instr. Meas.* **IM-19,** No. 1, 18-22 (Feb. 1970).

Key words: Adaptor; adaptor efficiency; adaptor evaluation; power measurement.

The problem of adaptor evaluation is of considerable interest in the UHF and microwave art where, because of the several different types of transmission line in common use, there is a frequent need to extend an established measurement capability in one type of line to other types of lines, e.g., from rectangular waveguide to coax.

In power and noise calibrations, it is the adaptor *efficiency* which is usually of interest, and one indication of the adaptor losses may be obtained by connecting an identical pair "back to back" and measuring the insertion loss of the combination by the usual techniques. If, then, the losses are assumed to divide equally between the two, the efficiency is thereby determined.

As a practical matter, the losses do not, in general, divide equally, which leads to an error whose evaluation is the subject of this paper. In particular it is shown that the method is capable of good accuracy provided that the assumed identity of the two adaptors is satisfied.

11620. Evenson, K. M., Wells, J. S., Matarrese, L. M., **Absolute frequency measurements of the CO_2 cw laser at 28 THz (10.6μm),** *Appl. Phys. Letters* **16,** No. 6, 251-253 (Mar. 15, 1970).

Key words: CO_2 laser; cw laser absolute frequency measurement; harmonic generation; high frequency mixing; H_2O laser; metal on metal diode.

The two highest cw absolute frequency measurements as yet reported are described. Frequencies of the $P(18)$ and $P(20)$ 10.6-μm lines from a cw CO_2 laser were found to be 28.359800 THz and 28.306251 THz ±0.000025 THz, respectively. The frequencies were measured by beating each of these lines with 3.8-THz (78μm) and 10.7-THz (28μm) radiation from a water vapor laser and a 26- to 28-GHz klystron in a tungsten-on-nickel point contact diode.

11621. Evenson, K. M., Wells, J. S., Matarrese, L. M., Elwell, L. B., **Absolute frequency measurements of the 28- and 78-μm cw water vapor laser lines,** *Appl. Phys. Letters* **16,** No. 4, 159-161 (Feb. 15, 1970).

Key words: Laser frequency measurement; 10.7 and 3.8 THz frequency measurement; 28 and 78 micron water vapor laser.

The two highest frequency measurements as yet reported are described. Frequencies of the 28- and 78-μm cw water vapor laser lines were found to be 10.718073±0.000002 THz and 3.821775±0.000003 THz, respectively, by beating each of these radiations with the 337- and 373-μm (0.89- and 0.80-THz) radiation from an HCN laser, in a metal-on-metal point-contact diode. The frequencies of the HCN laser were in turn measured by beating the 337-μm radiation with 74-GHz radiation and by measuring the 337- and 373-μm frequency difference.

11622. DiMarzio, E. A., Guttman, C. M., **Separation by flow,** *Macromolecules* **3,** No. 2, 131-146 (Mar.-Apr. 1970).

Key words: Chromatography; gel permeation chromatography; particle separation; polymer separation.

Dilute solutions of finite size particles undergoing Brownian motion and flowing through a capillary have average velocities which depend on the particle size. Thus one can obtain a separation of particles of different sizes due to fluid flow. The elution volumes of suspended particles or polymer molecules are derived for various tube geometries. Following Taylor, the effects of diffusional broadening of the volume elution peak for finite size particles are discussed and a criteria for separation is given. It is found that particles very similar in size can always be separated. A scheme for separation by flow on a continuous basis is proposed.

11623. Frederikse, H. P. R., **The electronic band structure of strontium titanate: Theory and experiment,** (Proc. Conf. International Advanced Study Institute: Electronic Structure in Solids, Chania, Crete, Greece, June 30-July 14, 1968), Chapter in *Electronic Structures in Solids*, pp. 259-269 (Plenum Press, New York, N.Y., 1969).

Key words: Electronic band structure; oxides; semiconductors; strontium titanate; transition metal compounds; transport measurements.

The approach used for calculating the electronic energy bands of $SrTiO_3$ is indicated. A number of experiments designed to test the result of this calculation is discussed. Among these are both transport measurements and optical investigations.

11624. Furukawa, G. T., Saba, W. G., Sweger, D. M., Plumb, H. H., **Normal boiling point and triple point temperatures of neon,** *Metrologia* **6,** No. 1, 35-37 (Jan. 1970).

Key words: Boiling point; neon; triple point.

The normal boiling point and triple point temperatures and the triple point pressure of neon were found to be 27.096±0.001 K and 24.553±0.001 K, and 43332±13 N/m^2 [325.02±0.10 mm Hg (0 °C)], respectively. (The temperatures are in terms of the NBS-1955 provisional temperature scale. The figures after the ±symbol indicate estimated uncertainties.) The triple point pressure is in accord with the more recent values, but the normal boiling point and triple point temperature deviate significantly from those of previous investigators.

11625. Gadzuk, J. W., **Resonance transmission in electron emission from surfaces with adsorbed atoms,** *Surface Sci.* **18,** 193-203 (1969).

Key words: Adsorption; electron emission; reflection resonance; transmission resonance.

Recent work on the effects of resonance tunneling through virtual bound states of adsorbed atoms on metal surfaces in field emission is extended to treat possible resonance transmission effects over adsorbed atoms in thermionic, auger, and photoelectron emission. The resonance effects are illustrated through exact calculations on model potentials for the metal and adsorbed atom. Shortcomings of the pseudopotential formulation of wave interference phenomenon are indicated. The transmission and transmission enhancement functions are calculated for an electron coming from within the metal which then crosses the combined potential of the metal surface and the adsorbed atom. Resonances in the transmission, similar to Ramsauer peaks, are predicted for suitable choices of model potential parameters which may be reasonable approximations to the parameters describing alkali atoms adsorbed on metal surfaces.

11626. Graminski, E. L., **The stress-strain behavior of accelerated and naturally aged papers,** *Tappi* **53,** No. 3, 406-410 (Mar. 1970).

Key words: Accelerating (process); aging; break resistance; cross-linking; crystal structure; dimensional stability; paper; strains; stiffness; stresses.

The extensional stiffness generally increases when paper is aged under accelerated conditions, indicating that either cross-linking occurs or that the degree of crystallinity increases. Either of these processes could be responsible for the increase in wet-strength when paper is heated. An increase in wet strength also occurs in the course of natural aging, indicating that some similarity exists between accelerated and natural aging.

11627. Gross, D., Natrella, M. G., **Interlaboratory comparison of the potential heat test method,** *Am. Soc. Testing Mater. Spec. Tech. Publ.* **464,** *Fire Test Performance,* pp. 127-152 (1970).

Key words: Calorimetry; combustibility; evaluation; fire tests; heat of combustion; interlaboratory tests; oxygen bomb; potential heat; tests.

Quantitative measurements of the total heat release by selected building materials were made during an interlaboratory study of the Potential Heat Method. Seven of the eleven participating laboratories ranked the five materials in the same order, and a single ranking change for three other laboratories would yield identical rankings. The general magnitude of within-laboratory repeatability and between-laboratory reproducibility for composite materials of generally low potential heat are indicated by statistical analysis of the results.

Results are reported on the effect of the amount of combustion promoter used and on differences in the first and second phase values. A discussion is presented on the effects of material sampling and on certain features of the experimental procedure which require special care. A tentative test method standard, containing complete details of the test procedure, is included as an appendix.

11628. Guildner, L. A., Stimson, H. F., Edsinger, R. E., Anderson, R. L., **An accurate mercury manometer for the NBS gas thermometer,** *Metrologia* **6,** No. 1, 1-18 (Jan. 1970).

Key words: Capacitance; diaphragm pressure transducer; environment; meniscus characteristics; mercury manometer; pressure; pressure regulator; vacuum joints; vacuum valves; wring tests.

A mercury manometer using capacitance sensing of meniscus positions has been refined to give an accuracy within 2 parts in 10^6 of the pressure in the range from 1×10^4 to 1.3×10^5 N/m^2. The determination of pressure ratios is accurate within 1.5 parts in 10^6 for pressures in the same range.

11629. Haber, S., **Sequences of numbers that are approximately completely equidistributed,** *J. Assoc. Computing Mach.* **17,** No. 2, 269-272 (Apr. 1970).

Key words: Equidistribution; numerical analysis; pseudo-random; quadrature; random numbers; sequences; uniform distribution.

For certain computational purposes, it is desirable to have sequences of numbers that are completely equidistributed, i.e. such that $t_1, t_2, \ldots$ is equidistributed in the interval [0,1]; (t_1, t_2), $(t_2, t_3), \ldots$ is equidistributed in the unit square; (t_1, t_2, t_3), $(t_2, t_3, t_4), \ldots$ is equidistributed in the unit cube; etc. The construction of such sequences is apparently quite complicated. For calculations using no more than a fixed number l of significant figures, the numbers in such a sequence must be rounded or truncated, and this results in a certain unavoidable minimum error in their distribution. In the paper this error is defined, and a simple construction is given of some sequences of l-digit numbers completely equidistributed to within the minimum error.

11630. Handy, L. B., Brinckman, F. E., **Chemistry of the methoxyfluorotungsten(VI) series,** *Chem. Commun.* pp. 214-215 (1970).

Key words: Fluorine; methoxy; n.m.r.; siloxane; stereochemistry; synthesis; tungsten.

The series of compounds $(MeO)_nWF_{6-n}$, $n = 1-5$, has been prepared by the reaction of WF_6 and Me_3SiOMe and the stereochemical configuration of each member has been assigned on the basis of ^{19}F and ^1H n.m.r. data.

11631. Heinrich, K. F. J., **Electron and ion microprobe analysis,** (Proc. 10th Symp. Electron, Ion, and Laser Beam Technology, Gaithersburg, Md., May 21-23, 1969), Chapter in *Record of the 10th Symposium on Electron, Ion, and Laser Beam Technology,* L. Marton, ed., pp. 353-360 (San Francisco Press, San Francisco, Calif., 1969).

Key words: Electron microprobe; ion microprobe; mass spectrography; microanalysis; scanning electron microscopy; x rays.

This review covers the principles and development of electron probe microanalysis, with particular emphasis on recent developments. The double function of the instrument as a spectrograph and as a microscope is considered. The salient characteristics of the ion beam microprobe are also indicated.

11632. Heinrich, K. F. J., Yakowitz, H., **Quantitative electron probe microanalysis: Uncertainty in the atomic number correction,** *Mikrochim. Acta* **7,** No. 1, 123-134 (Jan. 1970).

Key words: Atomic number correction; Bethe's Law; electron backscatter; error propagation; mean ionization potential; microprobe analysis.

The atomic number effect in quantitative electron probe microanalysis has been considered from the point of view of error propagation. The results indicate that the chief causes of analysis uncertainty are poorly known electron backscattering factors and mean ionization potential values. Operating variables such as working voltage or x-ray take-off angle cannot be manipulated so as to reduce the effect of the uncertainties. However, the overall analysis uncertainty remains nearly constant over the entire range of working voltages practical for microanalysis.

11633. Horn, W. A., **Optimal networks joining n points in the plane,** (Proc. IVth International Symp. The Theory of Traffic Flow, Karlsruhe, Germany, June 18-20, 1968). Chapter in *Strassenbau und Strassenverkehrstechnik* **86,** W. Leutzbach and P. Baron, eds., pp. 160-166 (Bundesminister für Verkehr, Germany, 1969).

Key words: Optimal interchange location; optimal networks; optimal road layout; planar graphs; planar networks; road location; Steiner's problem; street-network problem; transportation theory.

This report develops a number of results on the problem of connecting n points in the plane, with given travel demands between each pair, by a minimum-cost network. The critical assumptions are (a) constant construction costs per mile, (b) constant travel cost per mile per traveller, and (c) use of shortest paths in the network for all travel.

These results are adequate to give a complete solution when n = 3. For this case, the possible optimal network configurations are identified, each is shown actually to arise as the optimum for suitable combinations of problem data, and the computations necessary to choose among them are described. One of the results for general n is an upper bound (roughly $n^2/4$) on the number of nodes, other than the original n points, in an optimal network. Another is the determination of an explicit threshold, for the ratio of construction cost to travel cost, beyond which each "auxiliary node" will lie on exactly three links.

11634. Hummer, D. G., **Observatory Report—Joint Institute for Laboratory Astrophysics of the National Bureau of Standards and the University of Colorado,** *Bull. Am. Astron. Soc.* **2,** No. 1, 59-65 (1970).

Key words: Annual summary of astrophysics at JILA.

This is an annual report of work at JILA in astrophysics, and work in atomic physics that is immediately relevant to astrophysics. A list of publications for the period July 1, 1968-June 30, 1969 is appended.

11635. Kasen, M. B., **Grain boundary resistivity of aluminum,** *Phil. Mag.* **21,** No. 171, 599-610 (Mar. 1970).

Key words: Aluminum; electrical resistivity; grain boundaries; recrystallization; solute segregation; super-purity metals.

Residual resistivity at 4 K has been studied as a function of grain boundary area per unit volume in aluminium of two differing purities. A positive correlation between residual resistivity and boundary area was observed above a minimum boundary area per unit volume. The resistivity attributable to the presence of grain boundaries was found to reflect both the defect structure of the boundaries and the solute redistribution due to boundary segregation. Elimination of the solute effect yielded a specific boundary resistivity of $1.35 \pm 0.5 \times 10^{-12}$ ohm-cm² for pure boundaries. Evidence of a purification effect due to grain boundary segregation was noted.

11636. Kokoszka, G. F., Brinckman, F. E., **Electron paramagnetic resonance studies of phosphorus-containing reactive intermediates,** *J. Am. Chem. Soc.* **92,** No. 5, 1199-1205 (1970).

Key words: EPR; free radicals; irradiation; low-temperature reaction; methylchlorophosphines; phosphorus halides.

Several novel phosphorus-containing radicals have been produced at −196° by photolytic methods and characterized by epr spectrometry. In addition to the formation of PCl_2 (A(P) = 92 MHz; $g = 2.018$) in neat parent PCl_3, a secondary reaction has been observed which yields PCl_4 (A(P) = 3398 MHz; A'(Cl) = 175 MHz; A''(Cl) = 21 MHz; $g = 2.013$). Appropriate modification of the parent matrix by either cocondensation of inert diluent (Xe) or possibly reactive materials (PF_3, $SnCl_4$) results in useful additional spectral information. Thus in PF_3:PCl_3 (1:10) the full anisotropy of PCl_2 is revealed ($A_{||}$(P) = 753 MHz; $A_{\perp}$(P) = 78 MHz; $A_{||}$(Cl) = 41.5 MHz; $A_{\perp}$(Cl) = 0 MHz; $g_{||} = 2.001$; $g_{\perp} = 2.021'$. In contrast to neat PCl_3, irradiation of Xe:PCl_3(9:1) does not result in formation of PCl_4, presumably from inhibition of $Cl + PCl_3 \rightarrow PCl_4$ by competitive Cl recombination. Irradiation of $SnCl_4$:PCl_3(6:1) results in formation both of PCl_2 and PCl_4. Several related organophosphines were also irradiated, but only with CH_3PCl_2 was evidence obtained suggesting formation of a four-coordinate radical similar to PCl_4 (A(P) = 3015 MHz, $g = 2.000$). In all cases, however, epr data are consistent with bond scission of the ternary phosphine to produce PCl_2-like fragments. The above results are discussed in light of their bearing on the role of reactive intermediates in synthetic chemistry, and considerations of molecular geometric and orbital composition are presented with reference to current MO and electrostatic models.

11637. Kose, V. E., Sullivan, D. B., **Influence of external noise on microwave-induced Josephson steps,** *J. Appl. Phys.* **41,** No. 1, 169-174 (Jan. 1970).

Key words: Electromagnetic noise; fundamental constant; Josephson effect; superconductivity.

The influence of fluctuations on microwave-induced Josephson steps is treated phenomenologically and it is found that the center voltage of these steps is not shifted by the disturbance. Expressions governing the step shape are obtained for various noise spectra. The theory was checked by subjecting niobium point-contact junctions to several forms of externally generated noise. The theory does not differentiate between internal and external noise sources, so that a number of the conclusions can be extended to intrinsic fluctuations.

11638. Kuriyama, M., **The dynamical scattering amplitude of an imperfect crystal,** *Acta Cryst.* **A26,** No. 6, 56-59 (Jan. 1970).

Key words: Dynamical theory; imperfect crystal; line broadening; scattering amplitude; x-ray diffraction.

A formal expression for the x-ray dynamical scattering amplitude of an imperfect crystal is obtained. The resultant expression includes the dynamical line broadening effect on the diffracted x rays caused by imperfections. The effect due to absorption in the crystal are also taken into account.

11639. Kushner, L. M., **Are there standards?,** (Proc. National Safety Congress Conf., Chicago, Ill., Oct. 28, 1969), *National Safety Congress Trans., Civic Leadership* **6,** 12-16 (1969).

Key words: Consumers; safety; standards; voluntary standards.

Safety standards for consumer products are too few and too concentrated on a few classes of products. Perhaps the best way for consumers to remedy this situation is to make their voice heard in an organized and effective manner in the existing voluntary standards-making procedure.

11640. Lafferty, W. J., Maki, A. G., Coyle, T. D., **High resolution infrared spectrum and structure of diborane,** *J. Mol. Spectr.* **33,** No. 2, 345-367 (1970).

Key words: Bond angles; boron-boron bond length; boron hydrogen bond lengths; diborane; high resolution; infrared spectrum; molecular structure; rotational constants.

The two infrared active terminal B−H stretching bands, ν_8 and ν_{16}, of $^{10}B_2H_6$ and $^{11}B_2H_6$ were studied with a resolution of 0.04−0.05 cm^{-1}. The following ground state rotational constants were obtained: for $^{10}B_2H_6$, $A_0 = 2.65550 \pm 0.00056$ cm^{-1}, $B_0 = 0.642190 \pm 0.000080$ cm^{-1}, and $C_0 = 0.587372 \pm 0.000066$ cm^{-1}; for $^{11}B_2H_6$, $A_0 = 2.65569 \pm 0.00026$ cm^{-1}, $B_0 = 0.606463 \pm 0.000068$ cm^{-1} and $C_0 = 0.557279 \pm 0.000056$ cm^{-1}. These constants were used to derive the following structural parameters: $B \cdots B = 1.762_8 \pm 0.0026$ Å, $B-H_t = 1.200_5 \pm 0.0036$ Å, $B-H_b = 1.320_4 \pm 0.0010$ Å, $\angle H_tBH_t = 121.0 \pm 0.6°$ and $\angle H_bBH_b = 96.2 \pm 0.2°$. (All errors cited are twice standard deviations.) Upper state constants are reported.

11641. Lawton, R. A., Allred, C. M., Hudson, P. A., **A wide-range cw power measurement technique,** *IEEE Trans. Instr. Meas.* **IM-19,** No. 1, 28-34 (Feb. 1970).

Key words: Receiver calibration; RF power, measurement.

An accurate power measurement technique is described, which makes possible the determination of the net power delivered to a load of arbitrary impedance over a wide power range. A standard power meter is employed to fix a reference power level. Subsequent measurements consist of dimensionless ratios that can be obtained from precision attenuators.

The method is applicable to a very wide range of frequencies and was demonstrated at a frequency of 30 MHz with power measurements extending from 10^{-2} to 10^{-14} watt. Maximum uncertainties ranged from ~0.5 to 1.5 percent.

This technique is applicable in the measurement of the sensitivity of very-low-level detectors, receivers, radiometers, etc.

11642. Larson, W., Desch, R. F., Gillard, B. F., **Further analysis of the off-null versus power ratio method of attenuation measurement,** *IEEE Trans. Microwave Theory Tech.* **MTT-18,** No. 2, 112-113 (Feb. 1970).

Key words: Attenuation measurement; microwave; rotary-vane attenuator.

Analysis of calibration data of a rotary-vane attenuator has yielded closer agreement between the recently developed off-null and the proven power ratio methods of attenuation measurement. A constant bias was discovered in the measured values of attenuation difference, and a procedure is described to correct for this bias. After the correction is applied, the average agreement between the two methods of measurements is improved an order of magnitude, namely, from a former 2.0 percent to 0.17 percent.

11642A. Lutz, G. J., **Determination of oxygen in sodium by photon activation analysis,** *Anal. Chem.* **42,** No. 4, 531-532 (Apr. 1970).

Key words: Coincidence spectrometry; oxygen; photon activation analysis; rapid radiochemical separation; sodium.

A photon activation analysis method has been developed for the determination of oxygen in sodium. The method utilizes the photonuclear reaction $^{16}O(\gamma,n)^{15}O$. A rapid separation of the oxygen activity is effected by dissolving the sample in a dilute sodium hydroxide solution under flowing nitrogen. The radioactive oxygen is converted to sodium hydroxide which exchanges with the water. A portion of the water is distilled from the mixture and counted. Yields are approximately 50% and the time of separation is about four minutes. The detection limit is about 2 ppm. Standard deviations are typically 10%.

11643. McLaughlin, W. L., **Photographic film dosimeters,** Chapter in *Manual on Radiation Dosimetry,* N. W. Holm and R. J. Berry, eds., pp. 387-394 (Marcel Dekker, Inc., New York, N.Y., 1970).

Key words: Dosimetry; gamma rays; hypersensitization; internal image; latensification; photographic development; photolysis; physical development; printout; radiographic films; silver halides.

A recipe and response curves are given for several dosimetry films, and their interpretation of γ-ray exposures over a wide range is discussed. The procedures include using a number of special optical and chemical treatments, in order to broaden the conventional response from $3\times10^{-2}-10^{-3}$ roentgens to $10^{-3}-10^{8}$ roentgens. The special treatments include: Physical development, latensification plus physical development, stabilization processing. The advantages and disadvantages of these methods are outlined.

11644. McLaughlin, W. L., **Radiochromic dye-cyanide dosimeters,** Chapter in *Manual on Radiation Dosimetry,* N. W. Holm and R. J. Berry, eds., pp. 377-385 (Marcel Dekker, Inc., New York, N.Y., 1970).

Key words: Cyanides; dosimetry; dyes; electron beams; reflection densitometry; spectrophotometry; triphenyl methane; x- and γ-rays.

Triphenyl methane dye cyanide solutions (liquids, gels, films, and papers) have been developed for high-range dosimetry (10^3-10^8 rads). A recipe for their preparations, dose calibration by calorimetry, and spectrophotometric readout is included. The systems are shown to be highly versatile for radiation processing dosimetry.

11645. Mahler, R. J., **Nominal $\Delta m=\pm1$, 2, 3, 4, 5 magnetic nuclear transition probabilities in ruby,** *Phys. Rev.* **188,** No. 2, 584-590 (Dec. 1969).

Key words: Electric field gradients; electric quadrupole; magnetic dipole; nuclear spin system.

The nominal $\Delta m=\pm1$, 2, 3, 4, and 5 magnetic transition probabilities between Al^{27} nuclear energy levels in ruby are calculated, and the energy-level populations are determined with the presence of an external perturbation connecting two energy levels. A simple model where the relaxation of the Al^{27} spins is via a direct magnetic interaction with the Cr^{3+} paramagnetic impurity is used to compare the calculated $\Delta m=\pm2$ magnetic transition probability to the observed effects in a 4% Cr^{3+}-doped ruby sample. The calculated magnitude and angular dependence fit the experimental data and indicate that the effect is large enough to cause leakage effects when attempting a pure quadrupole saturation experiment in ruby.

11646. Mazur, J., **Higher order Markov chains and statistical thermodynamics of linear polymers,** Chapter 6 in *Markov Chains and Monte-Carlo Calculations in Polymer Science,* G. G. Lowry, ed., pp. 153-185 (Marcel Dekker, Inc., New York, N.Y., 1970).

Key words: Linear polymers; Markov chains; order-disorder transitions; random variables; restricted chains; Theta point; transition probabilities; volume exclusion.

The general theory of Markov chains is presented as it applies to linear polymer chains. The polymer chain is considered here as a linear sequence of consecutive events, upon which short-range intra-chain interactions are superimposed. The statistical and thermodynamic properties of these chains are obtained from the chain partition function, which is derived by the methods of averaging functions over the chains of random variables. The partition function and its various derivatives are calculated in terms of the eigenvalues and the eigenvectors of the matrices of the transition probabilities. In the various applications of the matrix method to the conformational properties of the linear polymer chains, the matrix of transition probabilities can be subsequently reduced by similarity transformations. The theory of Markov chains is applied, in particular, to the following problems: (1) the theory of the theta (ideal) point for lattice-simulated chains with short-range interactions, (2) volume exclusion problems for Markov chains, and (3) cooperative phenomena in linear polymers and the conditions for order-disorder transitions in self-interacting chains.

11647. Milligan, D. E., Jacox, M. E., **Infrared and ultraviolet spectra of the products of the vacuum-ultraviolet photolysis of silane isolated in an argon matrix,** *J. Chem. Phys.* **52,** No. 5, 2594-2608 (Mar. 1, 1970).

Key words: Disilane; free radical; infrared spectrum; matrix isolation; Si_2; SiH; SiH_2; SiH_3; silane; ultraviolet spectrum; vacuum-ultraviolet photolysis.

The vacuum-ultraviolet photolysis of silane and of the various deuterosilanes isolated in an argon matrix at 4 or at 14 K leads to the production of several reactive species. Infrared and ultraviolet spectroscopic evidence is presented indicating that Si_2, SiH, SiH_2, and SiH_3 are stabilized in these experiments. A previously unobserved transition of Si_2, tentatively identified as the $D(^3\Pi_u) - X(^3\Sigma_g^-)$ transition, is reported. Observation of the bending vibration absorption of SiH_2 at 1008 cm^{-1} has confirmed that the lower state of the previously observed electronic transition of singlet SiH_2 is the ground state of this species. The stretching vibrations of SiH_2 have also been observed near 2000 cm^{-1}. Infrared absorptions at 925, 996, 1955, and 1999 cm^{-1} have been tentatively assigned to SiH_3. The removal of one or more H atoms from SiH_4 leads to an appreciable lengthening of the remaining Si – H bonds. Disilane and incompletely characterized products of its photolysis contribute significantly to the infrared spectra observed at 14 K.

11648. Nargolwalla, S. S., Crambes, M. R., Suddueth, J. E., **Photon self-absorption corrections for the minimization of systematic errors in 14-MeV neutron activation analysis,** *Anal. Chim. Acta* **49,** No. 3, 425-436 (Mar. 1970).

> Key words: Annihilation radiation; correction factors; neutron and gamma-ray attenuation; photopeak analysis; removal cross section; systematic errors; 14-MeV activation analysis.

In comparative 14-MeV neutron activation analysis for oxygen, systematic errors are evidenced if attenuation of incident neutrons and induced gamma radioactivity by a thick sample is ignored. The present study pertains to the general case of measurement where photopeaks resulting from either direct nuclear transitions or from positron annihilation are counted. A quantitative evaluation of these attenuation processes is presented. The results show that the photon attenuation correction factor is related to the difference between the calculated linear absorption coefficients for sample and standard through a simple exponential expression. The slopes of the respective correction factor lines are compared with that for integral gamma counting in oxygen analysis. Differences in the magnitudes of the slopes are discussed. The results of this study are consistent with the removal cross section theory describing 14-MeV neutron attenuation over a wide range of threshold energies. Typical analyses of Standard Reference Materials, using these correction factors, are given.

11649. Nargolwalla, S. S., LaFleur, P. D., **Characterization of standard reference materials for industry and research by neutron generator activation analysis,** *Proc. American Nuclear Society Topical Meeting, San Juan, Puerto Rico, May 4-6, 1969*, pp. 183-186 (1969).

> Key words: Neutron generator activation analysis; organometallics; oxygen; standard reference materials; steels.

Described herein are examples which demonstrate the use of a low-cost neutron generator facility for materials characterization in the steel and oil industries. Analytical results for oxygen in steels and for the metallic component in a number of organometallic oil additives are given. The accuracy of these results is indicated by the close agreement of the activation data with that obtained by conventional and well proven chemical methods. These applications illustrate the utilization of standard materials useful for industrial and research needs.

11650. Newman, M., **A table of the first factor for prime cyclotomic fields,** *Math. Compt.* **24,** No. 109, 215-219 (Jan. 1970).

> Key words: Class numbers; cyclotomic fields; factorization; first factor.

The first factor of the prime cyclotomic fields for all primes <200 is computed by means of a determinantal formula, correcting some errors in tables of Kummer.

11651. Powell, F. X., Johnson, D. R., **Microwave detection of $H_2{}^{18}O$,** *Phys. Rev. Letters* **24,** No. 12, 637 (Mar. 23, 1970).

> Key words: Astrophysical; emission; galactic distribution of isotopes; $H_2{}^{18}O$; microwave absorption; rotational transition.

Laboratory detection of a microwave absorption in $H_2{}^{18}O$ near 5.33 cm is reported. This observed signal has been assigned to a pure rotational transition between the 6_{16} and 5_{23} levels in the ground vibrational state of $H_2{}^{18}O$. Signals from these same two rotational levels for $H_2{}^{16}O$ have been detected in emission from several sources in the galaxy.

11652. Rogers, E. E., Abramowitz, S., Jacox, M. E., Milligan, D. E., **Matrix-isolation studies of the infrared spectra of the free radicals CCl_3 and CBr_3,** *J. Chem. Phys.* **52,** No. 5, 2198-2204 (Mar. 1, 1970).

> Key words: Bromoform; carbon tetrabromide; carbon tetrachloride; CBr_3; CCl_3; chloroform; infrared spectrum; lithium atoms; matrix isolation; vacuum-ultraviolet photolysis.

CCl_3 has been stabilized both by the reaction of lithium atoms with CCl_4 in an argon matrix at 20 K and by the vacuum-ultraviolet photolysis of $HCCl_3$ or of $DCCl_3$ in an argon or a nitrogen matrix at 14 K. The analogous techniques have been found to lead to the stabilization of CBr_3. The product spectra obtained in the lithium-atom experiments are considerably simpler than those obtained in the previous studies of the reaction of lithium atoms with matrix-isolated CX_4. In the vacuum-ultraviolet photolysis experiments, $DCCl_2$, $HCBr_2$, and CBr_2 have also been observed. The absorption frequencies and contours obtained for ν_3 of CCl_3 and of CBr_3 are independent of the method used to produce these species, suggesting that lithium atoms and their reaction products do not appreciably perturb the degenerate stretching mode of either CCl_3 or CBr_3. Despite yields of these species comparable to those previously reported, absorptions at 674 and at 582 cm^{-1}, previously attributed to ν_1 of CCl_3 and CBr_3, respectively, are completely missing from the present experiments. No other absorption attributable to ν_1 of either species has been detected. It is concluded that a pyramidal (C_{3v}) structure for CCl_3 and for CBr_3 has not been established.

11653. Romanoff, M., **Corrosion evaluation of steel test piles exposed to permafrost soils,** *Proc. National Association of Corrosion Engineers 25th Conf., Houston, Texas, March 10-14, 1969*, pp. 6-13 (National Association of Corrosion Engineers, Houston, Texas, 1970).

> Key words: Corrosion; permafrost; pilings; soil corrosion; steel; steel piles; underground.

This paper describes the results of inspections made to investigate the corrosion of steel pilings in permanently frozen soils, and in the active or thin layer of soil above the permafrost layer, as part of the joint investigation conducted by the National Bureau of Standards and the U.S. Army Office of the Chief Engineers on the corrosion of steel piles in underground environments.

Nine steel test piles exposed in 3 soil sites at the Alaska Field Station of the U.S. Army Cold Regions Research and Engineering Laboratory at Fairbanks, Alaska, were extracted to investigate the extent of corrosion on the piles. The pipe- and H-pile specimens were exposed underground for 6, 8, or 11 years in an active horizon, in which the soil thaws and freezes annually to a depth of approximately 5 feet (1.5 m), and in permanently frozen soil beneath the active layer.

The test piles were installed to depths of 21 feet (6.4 m) below ground surface by several different methods.

Results of the inspections show that the steel piles are unaffected by corrosion in the permafrost regions, and that there was no evidence of significant corrosion at the ground line, in the active or thaw region, or at the boundary between the thaw and permafrost regions.

11654. Romanoff, M., **Performance of steel pilings in soils,** *Proc. National Association of Corrosion Engineers 25th Conf., Houston, Texas, March 10-14, 1969,* pp. 14-22 (National Association of Corrosion Engineers, Houston, Texas, 1970).

Key words: Corrosion; H-piles; sheet piles; soil corrosion; soils; steel piles; underground.

This paper consists of a summary of the results of inspections made on steel pilings in various underground structures to investigate the extent of corrosion on steel piles after many years of service in underground environments. This is part of an investigation being conducted by the National Bureau of Standards, in cooperation with the U.S. Army Corps of Engineers and the American Iron and Steel Institute.

Since the 1962 publication of the National Bureau of Standards Monograph 58, "Corrosion of Steel Pilings in Soils," additional data have been obtained from inspections of steel H- and sheet piles which have been exposed underground from 6 to 50 years in 35 structures in a wide variety of soil conditions.

At 18 locations the piles were pulled from the structures for inspection. At 17 locations, where it was not possible to pull the piles without disturbance to the existing structure, test holes were excavated adjacent to the sheet piling to expose at least an 8-ft width of steel on a section of the structure.

The results from the recent inspections are in agreement with, and substantiate, the observations previously made and published in Monograph 58.

The data show that, in general, pilings are not significantly affected by corrosion in undisturbed natural soils, regardless of the type of soil.

Piling exposed to fill soils, above or in the water table zone, appeared to be the most vulnerable to corrosion. However, only moderate corrosion in the form of localized pitting was generally found in these areas.

11655. Ruegg, F. C., Spijkerman, J. J., DeVoe, J. R., **A Mössbauer spectrometer for the structural analysis of materials,** (Proc. Symp. Radioisotope Instruments in Industry and Geophysics, Warsaw, Poland, Oct. 18-22, 1965), Chapter in *Radioisotope Instruments in Industry and Geophysics* **I,** 325-335 (International Atomic Energy Agency, Vienna, Austria, May 1966).

Key words: Materials; Mössbauer; spectrometer; structural analysis.

A Mössbauer spectrometer has been designed to provide high precision Mössbauer spectra. The instrument uses two electromechanical transducers, one driver and one sensor, in a feedback loop which incorporates an operational amplifier and a power amplifier. The transducer system is coupled to the scaler input of a multichannel analyzer. A high degree of synchronization between the channel number (which represents units of velocity) and the actual velocity produced by the transducer is obtained by using the analogue voltage of the channel number as the input to the electromechanical system. By advancing sequentially the channel number as a linear function of time, a motion of constant acceleration is produced. Gamma rays from the radiation detector proportional counter or the NaI(Tl) are then energy selected by a single channel pulse-height analyzer and these pulses are presented to the multiscaler input. The spectrometer can be used to accept high counting rates by using a unit scaler with a 10-MHz response.

The spectrometer can be used with a variety of auxiliary equipment to measure spectra at low temperature or high pressure.

The linearity of the spectrometer is found to be within ±0.1% relative standard deviation with the use of a voltage-to-frequency converter which is connected to the analyzer between the sensing transducer and the multiscaler input.

Some applications of this spectrometer to the analysis of materials are discussed.

11656. Santoro, A., Mighell, A. D., **Determination of reduced cells,** *Acta Cryst.* **A26,** No. 6, 124-127 (Jan. 1970).

Key words: Classification; identification; lattice; reduced cell.

An analysis is given of the relation between the reduced cells defined by Niggli and the cells obtained by applying Buerger's algorithm. It is shown that in many instances a cell based on the shortest three noncoplanar translations must be transformed to obtain the reduced cell. The required transformations for all cases have been derived and are presented in this paper.

11657. Schroeder, L. W., **Infrared and Raman spectra of $ClHCl^-$ and $BrHBr^-$ ions in $CsCl \cdot 1/3H_3OHCl_2$ and $CsBr \cdot 1/3H_3OHBr_2$,** *J. Chem. Phys.* **52,** No. 4, 1972-1978 (Feb. 1970).

Key words: $BrHBr^-$ ion; $ClHCl^-$ ion; environmental effects; infrared spectra; Raman spectra; symmetrical.

Infrared and Raman spectra of $CsCl \cdot 1/3H_3OHCl_2$ and $CsBr \cdot 1/3H_3OHBr_2$ have been measured in the 50-4000-cm^{-1} region. The spectra show the bands expected for the oxonium ion plus bands due to the XHX^- ion. The XHX^- ions are in a symmetrical environment, and a consistent interpretation of the spectra suggests that the XHX^- ions have a centrosymmetric structure in these salts.

11658. Schwerdtfeger, W. J., **Corrosion rates of metals, alloys, and galvanic couples as measured by polarization techniques,** *Mater. Res. Std.* **10,** No. 3, 22-28 (Mar. 1970).

Key words: Bridge circuit; change of pH; instantaneous corrosion rates; Pearson equation; pit depth; recorder; Stern-Geary equation; synthetic sea water; weight loss.

A variety of metals and alloys were exposed in the laboratory for 9 months in 340 gal. (1287 liter) of synthetic seawater held at 70 to 80 °F (21 to 27 °C). Corrosion currents calculated from polarization data obtained at periodic intervals were converted to weight losses by Faraday's law. The calculated weight losses were in reasonable agreement with the actual weight losses. Two techniques were used in calculating corrosion currents, namely, the Pearson method based on breaks in polarization curves and the Stern-Geary method based on polarization resistances. The two are considered to be complementary. The specimens, after cleaning and evaluating, were re-exposed to fresh synthetic seawater. The two polarization techniques were used to measure corrosion rates at periodically changed pH values of 8.5, 7.1, 5.6 and 4.2, and at pH 4.2 the effect on corrosion of water movement produced by compressed air was noted. It was observed that galvanic corrosion could be measured by the Pearson method when iron was coupled with other specimens which were cathodic.

11659. Snediker, D. K., **The Mössbauer effect of Sn^{119} in palladium-rich palladium—tin solid solutions,** (Proc. 2nd Symp. Mössbauer Effect Methodology, New York, N.Y., Jan. 25, 1966), Chapter in *Mössbauer Effect Methodology* **2,** 161-170 (Jan. 1966).

Key words: Intermetallic; Mössbauer; palladium alloys; Sn^{119m} source; solid solution; tin.

A study of the palladium-rich end of the palladium-tin alloy system has been conducted using the Mössbauer effect of Sn^{119m}. Alloy absorbers of composition from 1 to 16 atom % tin and the intermetallic Pd_3Sn were studied.

The Mössbauer parameters, e.g. fractional effect, half-width and chemical shift are reported for the various compositions. The Mössbauer spectrum of the alloy absorber has been determined to be a doublet consisting of spectra with chemical shifts corresponding to Pd_3Sn and the Sn-Pd solid solution.

A new source with a composition corresponding to Pd_3Sn was synthesized. Using this source with a β-10 absorber a spectrum was obtained with a half-width of 0.08 cm/s and an effect of 24%.

11660. Snelleman, W., **The measurement and calculation of flame temperatures,** Chapter 7 in *Flame Emission and Atomic Absorption Spectrometry* **1,** 213-239 (Marcel Dekker, Inc., New York, N.Y., 1969).

Key words: Equilibrium; flame calculations; flame composition; flame temperature; line reversal.

The concept of thermodynamic equilibrium and temperature is briefly described and the deviations from this equilibrium that occur in actual flame gases are discussed. The various methods of measuring flame temperatures are considered, with special attention to the method of line-reversal as to systematic and random errors. Next a description is given of the calculation of flame temperatures (with some examples) and finally a comparison is made between calculated and measured flame temperatures.

11661. Swiggard, E. M., Clabaugh, W. S., **Preparation of barium titanate semiconductors containing controlled amounts of neodymium,** *Am. Ceram. Soc. Bull.* **45,** No. 9, 777-781 (Sept. 1966).

Key words: Barium titanate; barium titanyl oxalate; neodymium; rare earths; semiconductors.

A procedure is described for coprecipitating known amounts of neodymium with barium titanyl oxalate tetrahydrate. Semiconductors prepared from this doped barium titanate are shown to have predictable electrical properties. Neodymium added (mole percent), precipitation temperature, addition rate, and excess acid modify the amount of neodymium that is coprecipitated. Electrical properties depend not only on the amount of neodymium present but also on how the neodymium was precipitated with the barium titanyl oxalate. A method is described for determining the amount of rare earth present in barium titanate.

11662. Venable, W. H., Jr., **Effects upon radiant intensity measurements due to scattering by optical elements,** *Appl. Opt.* **9,** No. 3, 609-615 (Mar. 1970).

Key words: Instrument function; iterative computations; nitrogen arc; radiance; radiant sources; scattering.

Measurements to determine the radiance of one portion of a nonuniform source can be strongly influenced by radiation from other portions of the source scattered by the optical system used to transmit the radiation to the detector. Conditions under which such scattering is important and procedures to correct for it are discussed. An illustration is provided from measurements made on a nitrogen arc source.

11663. Wells, J. S., Evenson, K. M., **A new LEPR spectrometer,** *Rev. Sci. Instr.* **41,** No. 2, 226-227 (Feb. 1970).

Key words: Laser electron paramagnetic resonance spectrometer; oxygen.

A new spectrometer for conducting laser electron paramagnetic resonance experiments on gases is described. This spectrometer yields at least an order of magnitude better sensitivity than the first spectrometer used in this type of investigation.

11664. West, E. D., Jennings, D. A., **Power measurement of large laser beams with a small dual-cone calorimeter,** *Rev. Sci. Instr.* **41,** No. 1, 142 (Jan. 1970).

Key words: Calorimeter; laser; laser calorimeter; laser energy; laser power.

Measurements of power and energy in large laser beams can be made with a small dual-cone calorimeter by covering the entire front surface with an aperture for the input cone. Irradiating only part of the front surface gives an error in the measurement.

11665. Wilson, W. K., **Record papers and their preservation,** *Chemistry* **43,** No. 3, 8-12 (Mar. 1970).

Key words: Degradation; paper; preservation of records; records; stability.

Variables in the papermaking process are discussed in relation to the stability of the finished product. Restoration methods, storage of records, and current research on preservation of records are described.

11666. Wims, A. M., Sengers, J. V., McIntyre, D., Shereshefsky, J., **Interfacial tension of 3-methylpentane-nitroethane near the critical point,** *J. Chem. Phys.* **52,** No. 6, 3042-3049 (Mar. 15, 1970).

Key words: Binary liquid mixtures; capillary rise; coexistence curve; critical phenomena; nitroethane; surface tension; 3-methylpentane.

Experimental data are reported for the capillary rise of the interface between the two liquid phases of 3-methylpentane-nitroethane as a function of temperature. The data are interpreted in terms of a power law currently proposed for the behavior of the interfacial tension near the critical mixing point. The results seem to indicate that for 3-methylpentane-nitroethane the region of asymptotic behavior is limited to rather small values of $\Delta T^* = (T_c - T)/T_c$. For $\Delta T^* \geqslant 10^{-2}$ Sugden's parameter a^2 can be represented by a power law $a^2 = A^2 \Delta T^{*\phi}$ with an exponent $\phi = 1.00 \pm 0.01$. A comparison is made with the behavior of the surface tension of simple one-component liquids near the gas-liquid critical point.

11667. Alley, C. O., Chang, R. F., Currie, D. G., Poultney, S. K., Bender, P. L., Dicke, R. H., Wilkinson, D. T., Faller, J. E., Kaula, W. M., MacDonald, J. F., Mulholland, J. D., Plotkin, H. H., Carrion, W., Wampler, E. J., **Laser ranging retro-reflector: Continuing measurements and expected results,** *Science* **167,** No. 3918, 458-460 (Jan. 30, 1970).

Key words: Geophysics; laser; lunar motion; selenology.

After successful acquisition in August of reflected ruby laser pulses from the Apollo 11 laser ranging retro-reflector (LRRR) with the telescopes at the Lick and McDonald observatories, repeated measurements of the round-trip travel time of light have been made from the McDonald Observatory in September with an equivalent range precision of ± 2.5 meters. These acquisition period observations demonstrated the performance of the LRRR through lunar night and during sunlit conditions on the moon. Instrumentation activated at the McDonald Observatory in October has yielded a precision of ±0.3 meter, and improvement to ±0.15 meter is expected shortly. Continued monitoring of the changes in the earth-moon distance as measured by the round-trip time of light from suitably distributed earth stations is expected to contribute to our knowledge of the earth-moon system.

11668. Astin, A. V., **Report on the symposium on an International Standard Reference Materials Program,** *Metrologia* **6,** No. 1, 33-34 (Jan. 1970).

Key words: Characterizing materials; measurement compatibility; standard reference materials.

Standard Reference Materials (SRM's), through a certifiable physical or chemical property of a given material, are an effective means for achieving measurement compatibility. The program has been highly successful in the United States, although even in this country there is an identifiable need for well over 200 additional SRM's.

There is a growing recognition of the urgent need for a coordinated international SRM program. Such coordination will not only reduce wasteful duplication but will greatly increase the world supply of needed SRM's. The problem was recognized, acknowledged to be of great importance, and recommendations were made to deal with it effectively.

11669. Baker, M. A., **Continuity of coating test and suggested applications,** Chapter in *Proceedings of the Porcelain Enamel Institute Technical Forum, Ohio State Univ., Columbus, Ohio, Nov. 4-6, 1969,* **31,** 71-84 (Porcelain Enamel Institute, Washington, D.C., 1969).

Key words: Continuity of coating; high-voltage; porcelain enamel; weather resistance.

The high-voltage method of determining the continuity of conventional porcelain enamel coatings has been developed into a standard test. Each high-voltage test instrument, either ac or dc, must be calibrated. Once the instruments have been calibrated, they can be used to locate both existing discontinuities and potential discontinuities, depending on the applied voltage. It has been shown that this test is effective in upgrading the quality of porcelain enamels used in exterior architectural applications and is also capable of determining hot water tank and direct-on enamels with good coverage.

11670. Baker, M. A., **A summary of the three year inspection of the 1964 exposure test of porcelain enamels on aluminum,** Chapter in *Proceedings of the Porcelain Enamel Institute Technical Forum, Ohio State Univ., Columbus, Ohio, Nov. 4-6, 1969,* **31,** 106-113 (Porcelain Enamel Institute, Washington, D.C., 1969).

Key words: Color; gloss; porcelain enamel on aluminum; weather resistance.

An exposure test of porcelain enamels on aluminum was initiated by the National Bureau of Standards and the Porcelain Enamel Institute in 1964. The enamels were returned from the exposure sites to the laboratory at NBS to be measured for changes in gloss and color after six months', one year's and three years' exposure. Changes were found to be greatest at Kure Beach and least at Montreal and Los Angeles, with moderate changes occurring at Washington and New York.

Although the boiling citric acid test is used as an acceptance test for these enamels, the correlation with color change, particularly at Kure Beach, was not as good as expected. A cupric chloride test was developed which shows an improvement in the correlation.

11671. Bennett, L. H., Swartzendruber, L. J., **On the interpretation of Mössbauer effect spectra as related to the constitution of Cu-Ni-Fe alloys,** *Acta Met.* **18,** No. 5, 485-498 (May 1970).

Key words: Alloys; Cu; Fe; metallurgy; Mössbauer effect; Ni.

Iron Mössbauer effect data are presented for copper-rich Cu-Ni-Fe alloys containing up to 53 at.% Ni and up to 8 at.% Fe. The problem of interpreting the complex Mössbauer effect spectra in these alloys is discussed in great detail. Phase separation, precipitation and effects of heat treatments are analyzed. A new feature of the Mössbauer spectrum for rapidly quenched Fe in Cu is reported. The use of an external magnetic field is shown to be an aid in identification of spectral features. The possibility of relevance to the Weiss theory of γ_1-, γ_2-Fe is noted. Results in Cu-Fe give a new upper limit of 2 at. % for the maximum solubility of Fe in Cu for samples quenched from the melt or from 1000 °C.

11672. Bjorge, S. E., Urbach, P. F., Earl, P. H., King, D. W., Wiederkehr, R. R. V., **An experiment to determine the effectiveness of various announcement media on Clearinghouse for Federal Scientific and Technical Information sales,** *Proc. American Society for Information Science Annual Meeting, Columbus, Ohio, Oct. 20-24, 1968,* pp. 327-329 (Greenwood Publ. Corp., New York, N.Y., 1969).

Key words: Clearinghouse; document announcement; document sales; information centers.

The Clearinghouse for Federal Scientific and Technical Information (CFSTI) collects government sponsored research reports, announces their availability, and sells copies to the general public. An experiment was designed, conducted, and analyzed to determine the effect of the various announcement media on CFSTI sales. The results of this experiment were used to modify the Clearinghouse announcement system so as to improve the quality of service and to increase the number of sales.

11673. Bjorge, S. E., Urbach, P. F., Earl, P. H., King, D. W., Wiederkehr, R. R. V., **Experimentation, modeling and analysis to establish a new pricing policy at the Clearinghouse for Federal Scientific and Technical Information,** *Proc. American Society for Information Science Annual Meeting, Columbus, Ohio, Oct. 20-24, 1968,* pp. 311-314 (Greenwood Publ. Corp., New York, N.Y., 1969).

Key words: Clearinghouse; cost analysis; document sales; information center.

This paper summarizes the results of experimentation, modeling and analysis performed in 1966 to develop a new pricing policy at the Clearinghouse for Federal Scientific and Technical Information. Analysis of request processing activities at CFSTI indicated that for a high proportion of requests the processing times were unsatisfactorily long and costs were unsatisfactorily high. Preliminary investigation indicated that a single unit selling price for all titles instead of a sliding scale price and the use of prepaid coupons would solve both of these problems. However, the question remained whether a unit-price policy should be adopted since the impact of this policy on the public demand and the Clearinghouse income was not known. These questions were answered, in part, by measuring demand at various price levels by experimentation, modeling and analysis which determined the effect of demand at the various price levels on income and cost. A nearly optimum unit price was chosen by this means and the new pricing policy has been implemented.

11674. Boesch, L., Napolitano, A., Macedo, P. B., **Spectrum of volume relaxation times in B_2O_3,** *J. Am. Ceram. Soc.* **53,** No. 3, 148-153 (1970).

Key words: Activation energy; annealing; Arrhenius behavior; B_2O_3 glass; distribution of relaxation times; relaxation times; volume relaxation times.

Time-index of refraction isotherms were measured for B_2O_3 glass starting from both a high and a low temperature in the transformation region. The equilibrium index values at each temperature, obtained from both types of approach curve, were identical. As in the case of the density values, the equilibrium refractive index curve as a function of temperature for this glass is not a straight line. The two-relaxation-times (cross over) model was applied to B_2O_3 glass and fitted the data as well as it did in previous experiments with borosilicate crown and GeO_2 glasses. The reverse crossover which was predicted by the model was experimentally confirmed with the B_2O_3 glass. The spectrum of relaxation times narrowed with decreasing temperature, indicating approach to another region of single relaxation associated with the low-temperature Arrhenius region. The relaxation times for the low-temperature crossover agreed well with those from the high-temperature curves, indicating complete linearity in the experiments. The spectrum of relaxation times was slightly asymmetrical at constant pressure and very asymmetrical at constant volume.

11675. Boswarva, I. M., **Semiempirical calculations of ionic polarizabilities and van der Waals potential coefficients for the alkaline-earth chalcogenides,** *Phys. Rev. B.* **1,** No. 4, 1698-1701 (Feb. 15, 1970).

Key words: Alkaline earth chalcogenides; electronic polarizabilities; Lorentz factor; oxides; sulfides; van der Waals coefficients.

Electronic polarizabilities for the ions of the alkaline-earth chalcogenides have been calculated by assuming an additivity law within the family of salts and a Lorentz factor of $4/3\pi$, and using experimental refractive indices and interionic distances. It is shown that the additivity assumption is well obeyed, and the Lorentz factor value of $4/3\pi$ gives the best fit to the data. Each polarizability obtained has been related to a mean excitation or characteristic energy for the ion, and hence the coefficients of the dipole-dipole and dipole-quadrupole terms of the van der Waals interaction energy derived.

11676. Branscomb, L. M., **The photoionization of one- and two-electron atoms,** (Proc. Sommerfeld Centennial Memorial Meeting, Munich, Germany, Sept. 10-14, 1968), Chapter in *Physics of the One- and Two-Electron Atoms,* F. Bopp and H. Kleinpoppen, eds., pp. 669-699 (North Holland Publ. Co., Amsterdam, The Netherlands, 1969).

Key words: Helium and their ions; review of photoionization of hydrogen.

Major advances in the physics of photoionization of one- and two-electron atoms (the isoelectronic series starting with H and H^-) are reviewed, with an emphasis on the extent to which theory and experiment are independently reliable and relatively in agreement. Great progress has been made in the last ten years in both theory and experiment because of a number of relatively recent developments: extremely accurate two-electron wave functions and photoionization cross section calculations, made possible by the computer; crossed beam methods for photoionization studies; the use of synchrotron radiation as an ultraviolet continuous light source; the development of the theory of autoionizing states and resonances; the use of high energy resolution electron scattering experiments in the energy range of Born approximation validity to study the distribution of oscillator strength in the atomic continuum. A number of interesting problems, however, remain unsolved.

11677. Broadhurst, M. G., Mopsik, F. I., **Bulk modulus and Grüneisen parameters for linear polymers,** *J. Chem. Phys.* **52,** No. 7, 3634-3641 (Apr. 1, 1970).

Key words: Anderson-Grüneisen parameter; bulk modulus; compressibility; Grüneisen constant; pair potential; paraffins; polyethylene; polymers; pressure; volume.

Expressions are derived for the isothermal bulk modulus B_T and Anderson-Grüneisen parameter δ for a simple two-dimensional bundle-of-chains model where parallel nearest-neighbor chains are assumed to interact with a simple separation-dependent potential. Bulk modulus data for general linear polymers are examined and shown to be essentially temperature independent at constant volume in accord with the model. The theory is shown to predict quite accurately for reasonable assumed pair potentials both B_T and δ of high-density polyethylene and n-paraffins with no adjustable parameters. The values of δ obtained for polyethylene from B_T data are in excellent agreement with those reported from ultrasonic data. The analysis is also shown to provide a sensitive measure of the form of the effective chain pair potential near its minimum. Also, a close relationship between δ and the Grüneisen constant γ is derived for this model.

11678. Bur, A. J., **Extrapolation to single-relaxation-time behavior in solutions of poly(n-butylisocyanate),** *J. Chem. Phys.* **52,** No. 7, 3813-3819 (Apr. 1, 1970).

Key words: Dielectric constant; dielectric relaxation time; dipole moment; distribution of molecular weights; distribution of relaxation times; poly(n-butylisocyanate); rodlike molecule; single relaxation time.

The dielectric relaxation time of rodlike poly(n-butylisocyanate) (PBIC), $(-CO-NR-)_n$, where $R = C_4H_9$, has been observed for dilute solutions as a function of the polydispersity in the PBIC molecular weight. The mode of relaxation is rotation about the minor axis of the rodlike molecule (end-over-end rotation). The dielectric relaxation time for this mode is a sensitive function of molecular weight, and a distribution of relaxation times $\Phi(\tau)$ is observed whenever a distribution of molecular weights $\Psi(M)$ is present. A one-to-one correspondence between $\Phi(\tau)$ and $\Psi(M)$ is established by observing the half-width $W/2$ of the dielectric dispersion on a log frequency plot as a function of the ratio M_w/M_n, where M_n and M_w are the number and weight averages of $\Psi(M)$. Extrapolation of the $W/2$ vs M_W/M_n data to the monodispersed case ($M_w/M_n = 1.0$) is carried out in order to determine whether or not a monodispersed sample has a single relaxation time. The accuracy of the extrapolated half-width suffers because the estimated uncertainty of the measured ratio M_w/M_n is $\pm 10\%$. The data do, however, satisfy a necessary condition for the presence of a single relaxation time. In the region $M_w/M_n = 1.0$ to 1.6, the experimentally observed M_w/M_n is in good agreement with M_w/M_n calculated from the observed $\Phi(\tau)$. For these calculations it is assumed that each molecular species has a single relaxation time and that the molecular dipole moment is proportional to the molecular weight. A distribution $\Psi(M)$ may be obtained from the observed $\Phi(\tau)$ if it can be assumed that all molecules have the same conformation.

11679. Burgess, A., Hummer, D. G., Tully, J. A., **Electron impact excitation of positive ions,** *Phil. Trans. Roy. Soc. London,* **266,** Ser. A., No. 1175, 225-279 (April 23, 1970).

Key words: Cross section; electron impact excitation; ionized helium; positive ion.

Non-relativistic Coulomb-Born-Oppenheimer reactance matrices and cross-sections are given for all transitions between the 1s, 2s and 2p states in He^+ and in hydrogen-like ions of large nuclear charge. From these results some cross-sections for intercombination transitions in highly charged nonhydrogenic ions are estimated.

11680. Burke, P. G., Gallaher, D. F., Geltman, S., **Electron scattering by atomic hydrogen using a pseudo-state expansion. I. Elastic scattering,** *J. Phys. B. (Proc. Phys. Soc.)* **2,** 1142 (1969).

Key words: Close coupling; elastic scattering; electron; hydrogen atom; polarizability; pseudo-states.

A modified close coupling expansion has been developed and applied to calculate elastic electron-hydrogen atom scattering phase shifts. This expansion into a complete, discrete, orthonormal basis set is a variant of the more usual close coupling expansion into eigenstates of the target Hamiltonian. We retain the first few hydrogen atom eigenstates and augment these terms with pseudo-states chosen, in our particular case, to incorporate fully the ground state polarizability of the hydrogen atom. The resulting phase shifts are compared, where possible, with those obtained in the most accurate variational calculations available, and they indicate a distinctly improved convergence over those obtained in the close coupling expansion.

11681. Burke, R. W., **Exchange reactions of ternary ion association complexes directly in the organic phase,** *Talanta* **17,** 240-242 (1970).

Key words: Directly in organic phase; exchange reactions; spectrofluorometric; spectrophotometric; ternary ion association complexes; trace.

A new approach has been developed that combines the advantages of solvent extraction with the inherently high sensitivities afforded through the incorporation of large organic dye cations into ternary ion-association complexes containing the metal ion of interest. Basically, the new technique involves the formation of a complex, $[ML_x^-]R^+$, where R^+ initially is either a non-colored or a non-fluorescent organic cation. Following extraction of $[ML_x^-]R^+$ a second cation, R_1^+, which is capable of exchanging with the first R^+ group, is added directly to the organic phase. In this instance, however, R_1^+ is purposely selected to be highly colored or fluorescent, thereby yielding the highly colored or fluorescent complex $[ML_x^-]R_1^+$. Unreacted R_1^+ is readily back-extracted, leaving only the dye-complex in the organic phase. In the present paper the determinations of gold and uranium are described to illustrate the advantages of the new technique.

11682. Burke, R. W., Deardorff, E. R., **Simultaneous spectrophotometric determination of cobalt, nickel and copper and 2,3-quinoxalinedithiol,** *Talanta* **17,** 255-264 (1970).

Key words: Aqueous ethanol; cobalt; colored complexes; copper; least squares treatment data; nickel; simultaneous spectrophotometric; 2,3-quinoxalinedithiol.

In aqueous ethanol cobalt(II), nickel(II) and copper(I) react instantaneously with 2,3-quinoxalinedithiol at pH 2 to form strongly colored complexes exhibiting absorption maxima at 510, 606 and 665, and 625 nm, respectively. At pH 6 the reaction of copper can be virtually eliminated, while the cobalt and nickel reactions show only small decreases in sensitivity. This behavior has been made the basis of a rapid method for the simultaneous determination of these three elements. The absorbances of the complexes have been found to be additive for all combinations of these elements in which the individual concentrations have been varied from approximately 0.1 to 1 ppm. A least-squares estimate of the concentration of any of the elements may be readily obtained by using a simple linear equation based on the absorbance readings and a set of constants derived from the spectrophotometric data. The analyses of seven synthetic solutions and four NBS Standard Reference Materials yielded a maximum error of 6.0% and an average error of 1.6%.

11683. Burns, G. W., Hurst, W. S., **An investigation of W-3% Re and W-25% Re thermoelements in vacuum, argon and hydrogen,** *NASA Final Report* **CR-72639,** 1-28 (National Aeronautics and Space Administration, Greenbelt, Md., Mar. 10, 1970).

Key words: Argon; evaporation; exposure; hydrogen and high vacuum environments; metallographic examination; stability; thermal emf; W-3% Re and W-25% Re thermoelements.

The effect of exposure of bare wire W-3% Re and W-25% Re thermoelements to environments of high vacuum ($< 1 \times 10^{-8}$ torr), Argon and Hydrogen at temperatures ranging from 2200 K to 2600 K for periods up to 1000 hours has been investigated. The individual thermoelements, and hence the W-3% Re versus W-25% Re thermocouple pair, experienced a shift in the emf-temperature relationship on initial heating. In Argon and Hydrogen, the shift was less than 1% at 2000 K for the thermocouple pair. After the initial shift, the thermoelements exposed in Argon and Hydrogen experienced no significant further change in their emf-temperature relationship for periods up to 1000 hours. Both the W-3% Re and the W-25% Re thermoelements, when exposed in vacuum at 2400 K and above, drifted continually from original calibration as a result of preferential loss of Re by evaporation. The thermoelements were examined for chemical and structural changes by electron microprobe analysis and by conventional metallographic techniques.

11684. Cassidy, E. C., Cones, H. N., **Electro-optical observations and measurements of distorted high-intensity electric fields,** *Proc. Conf. Electrical Insulation and Dielectric Phenomena, Buck Hill Falls, Pa., Oct. 20-22, 1969,* pp. 77-86 (National Academy of Sciences, Washington, D.C., 1970).

Key words: Dielectric liquids; electro-optical measurements; electrostatic field measurements; high voltage measurements; Kerr cell.

The electric field between electrodes immersed in a dielectric liquid is often distorted by the presence of space charge, thus making analytical determination of the field distribution extremely difficult. This work utilizes laser light for Kerr electro-optical analysis of distorted electric fields imposed when high direct voltages are applied to nitrobenzene-filled Kerr cells. Two-dimensional fringe images, similar to those achieved in photoelastic mechanical stress analysis, are observed. Regions of high electrical stress are detected directly from concentrations of a greater number of fringes. Field profiles observed with voltages as high as 90 kV applied to cells with various interelectrode distances are presented. Space-resolved measurements of relative field strength, actual field strength (in V/cm) and potential are also derived. The measurement techniques employed are believed to be accurate within 1%.

11685. Cooper, M. J., **Critical indices of the Z-L polymer folding transition,** *J. Chem. Phys. Letter* **52,** No. 1, 473-474 (Jan. 1, 1970).

Key words: Critical indices; critical phenomena; phase transition; polymer crystallization; Zwanzig-Lauritzen model.

The critical indices for the Zwanzig-Lauritzen polymer crystallization transition are identified and shown to satisfy the thermodynamic equalities.

11686. Fishman, L., Mountain, R. D., **Activity coefficients of solutions from the intensity ratio of Rayleigh to Brillouin scattering,** *J. Phys. Chem.* **74,** No. 10, 2178-2182 (May 14, 1970).

Key words. Activity coefficients; binary mixture; Brillouin scattering; fluctuations; light scattering from solutions; Rayleigh scattering; thermal relaxation; volume viscosity.

The ratio of the intensity of Rayleigh to Brillouin scattered light for a binary mixture with internal degrees of freedom is determined by calculating the frequency spectrum of fluctuations in concentration, temperature, and pressure. Thermodynamic fluctuation theory and linearized hydrodynamic equations, modified to include the internal degrees of freedom through a frequency-dependent volume viscosity, are employed in the calculation. The intensity ratio is of interest as it may be used to determine activity coefficients. A method of doing so when the system contains internal degrees of freedom is described.

11687. Fraker, A. C., Ruff, A. W., Jr., **Microstructural studies of 7075 Al-relation to the directional sensitivity for stress corrosion cracking,** *Corrosion Sci.* **10,** 191-195 (1970).

Key words: Aluminum alloys; corrosion; dislocations; electron microscopy; precipitates; stress corrosion cracking.

Dislocation and precipitate distributions have been studied in stress corrosion samples produced from commercial 7075 Al rolled plate. Transmission electron microscopy results show that the dislocation and precipitate distributions are similar in thin sections parallel to the three principal planes and are relatively uniform from the grain boundaries to the inner grain regions. It is concluded that variations in the precipitate and dislocation structures in this alloy are not responsible for the pronounced directional sensitivity for s.c.c.

11688. Gadzuk, J. W., **Coupled surface-plasmon modes in metal-thin-film-vacuum sandwiches,** *Phys. Rev. B*, **1**, No. 3, 1267-1269 (Feb. 1, 1970).

Key words: Adsorption; electron emission; junctions; low energy electron diffraction; plasma oscillations.

The normal surface-plasmon modes for a thin-layered plasma bounded on one side by a semi-infinite plasma and on the other side by a vacuum are determined. The characteristic frequencies of the coupled modes resulting from surface oscillations of the plasma-plasma interface and the plasma-vacuum interface are found. The relevance of these results to recent experiments by MacRae, Müller, Lander, Morrison, and Phillips is indicated.

11689. Gallagher, A., **State-transfer collisions,** (Proc. Sommerfeld Centennial Memorial Meeting, Munich, Germany, Sept. 9-14, 1968), Chapter in *Physics of the One- and Two-Electron Atomics*, F. Bopp and H. Kleinpoppen, eds., pp. 788-794 (North Holland Publ. Co., Amsterdam, The Netherlands, 1969).

Key words: Alkalis; excitation transfer; helium.

The changes in state populations that occur in thermal atom-atom collisions will be discussed. Particular emphasis will be given to nearly adiabatic helium and alkali excitation transfer.

11690. Goltz, S. M., Tanner, C. B., Thurtell, G. W., Jones, F. E., **Evaporation measurements by an Eddy correlation method,** *Water Resources Res.* **6**, No. 2, 440-446 (Apr. 1970).

Key words: Eddy correlation; humidity sensor; vapor flux.

Eddy correlation measurements of water vapor flux density have been made using a barium fluoride film humidity sensor and a three-dimensional anemometer. During morning and evening periods, good agreement was obtained between Eddy correlation data and two independent methods. Serious disagreement between measurements occurred only when the humidity sensor was operating within a portion of the calibration curve which was not suited to the on-line computer calculations. The results indicate that the humidity sensor could be modified to allow operation at all times within linear segments of the calibration curve and permit successful on-line computer calculations of Eddy correlation vapor flux within one meter of the surface.

11691. Gugeler, A. L., **A study of the adherence of porcelain enamel to aluminum,** Chapter in *Proceedings of the Porcelain Enamel Institute Forum, Ohio State Univ., Columbus, Ohio, November 4-6, 1969*, **31**, 37-45 (Porcelain Enamel Institute, Washington, D.C., 1969).

Key words: Adherence; aluminum oxide; conversion chromate coating; electron microprobe; electron microscope; magnesium; porcelain enamel on aluminum.

The Porcelain Enameled Aluminum Council of the Porcelain Enamel Institute has been conducting a study of the adherence of porcelain enamels to aluminum. The work thus far indicates that the nature of the oxide layer on the metal is important to the adherence of porcelain enamel. If this layer is essentially pure aluminum oxide, the enamel adheres well. If the oxide layer contains magnesium, spalling may result. The adherence of enamels to alloys containing magnesium is improved if the metal surface is chromated before enameling.

11692. Hummer, D. G., **Spectral line formation by noncoherent scattering with a dipole phase-function,** *Astrophysical Letters* **5**, 1 (1970).

Key words: Anisotropic scattering; limb darkening; noncoherent scattering; Rayleigh scattering; spectral line formation.

Results are presented for lines formed by atoms scattering photons with complete redistribution in frequency and a dipole (Rayleigh) phase function. For optical thicknesses on the order of unity the ratio of limb ($\mu \simeq 0.2$) to disc intensity for dipole scattering is about 5% larger than for isotropic scattering, at all frequencies. For larger optical thickness ($\geqslant 10^2$), the limb-to-disc ratio is about 2% lower for dipole than for isotropic scattering within a Doppler halfwidth of the line center and unity in the line wings. Some quantitative information is given on the angular distribution of the radiation field. An exact relation between two moments of the radiation field at the surface of a semi-infinite, isothermal medium is presented.

11693. Landgrebe, W. B., Mann, W. B., Schima, F. J., **The distribution of 70-kV praseodymium ions in iron foil and a technique for removing thin layers of iron,** *Intern. J. Appl. Radiation Isotopes* **21**, No. 3, 169-171 (Mar. 1970).

Key words: Barium-140; iron foils; praseodymium-142; thulium-170.

The NBS isotope separator has been used to implant barium-140, praseodymium-142 and thulium-170(1) into iron foils for nuclear-orientation studies at low temperatures. In the case of praseodymium, stripping experiments were carried out to determine the depth of penetration. The profile of the beam was also determined.

11694. McKinney, J. E., Oser, H. J., **Stability of acoustic waves within a viscous compressible heat-conducting fluid,** *J. Acoust. Soc. Am.* **47**, No. 3, 781-785 (March 1970).

Key words: Absorption; acoustic propagation; fluids; Kirchhoff-Langevin; Navier-Stokes; stability; thermal conductivity; viscosity.

The question of stability of propagation of acoustic waves within a continuum of compressible viscous heat-conducting fluid has been investigated. A bounded solution (i.e., a stable solution) is assured if either of the following two conditions is satified:

$$\gamma = 1 \tag{i}$$

or

$$\frac{3(2-\gamma)}{4[1+(3/4)(v/\eta)]P} \leqslant 1 \text{ (for } \gamma > 1), \tag{ii}$$

where P is the Prandtl number, γ the ratio of specific heats, and v and η the bulk and shear viscosities, respectively. According to the theory, the above inequality must be obeyed for all passive fluids with $\gamma > 1$. Using experimental values for many different fluids, it appears to be generally obeyed except for the molten metals including mercury and, possibly, the superfluids.

11695. Margoshes, M., Scribner, B. F., **Emission spectrometry,** *Anal. Chem.* **42**, No. 5, 398R-417R (April 1970).

Key words: Emission spectrometry; excitation sources; review; spectrochemical analysis; trace analysis.

The literature on optical emission spectrometry is reviewed for the period 1968-69, with emphasis on areas of importance to spectrochemical analysis. Major topics covered are books and reviews, spectral descriptions and classifications, instrumentation, calibration, excitation sources, trace analysis, lasers and microanalysis, and applications.

11696. Marton, L., **Survey of microanalysis—interpolation and extrapolation,** Chapter in *Electron Probe Microanalysis*, pp. 1-14 (Academic Press Inc., New York, N.Y., 1969).

Key words: Electron probe; microanalysis.

A review of the early history of the efforts to achieve a chemical analysis of very small areas of the surface of a specimen; besides the electron probe microanalyzer, it includes other less successful attempts. Looking in the future, a few possible improvements are discussed together with expected applications.

11697. Milligan, D. E., Jacox, M. E., Guillory, W. A., **Infrared spectrum of NO_2-ion isolated in an argon matrix,** *J. Chem. Phys.* **52,** No. 8, 3864-3868 (April 15, 1970).

Key words: Alkali metal atoms; electron bombardment; infrared spectrum; matrix isolation; nitrite anion; nitrogen dioxide; photodetachment; photoionization; vacuum-ultraviolet photolysis.

The molecular ion NO_2^- has been stabilized in an argon matrix in sufficient concentration for detection of its antisymmetric stretching fundamental, ν_3, at 1244 cm^{-1} by electron bombardment or photoionization of matrix-isolated NO_2 and by the interaction of an alkali-metal atomic beam with NO_2 in an argon matrix. In contrast to the position of this fundamental in an inert, nonionic environment, a value of approximately 1275 cm^{-1} is characteristic of the crystalline material. Isotopic data are consistent with a 115° valence angle for NO_2^-, independent of environment. Irradiation of the sample with light of wavelength near 3150 Å leads to the destruction of the NO_2^- absorption in the studies of the electron bombardment and photoionization of NO_2, but not in the experiments in which the alkali metal atoms provide a reservoir of photoelectrons.

11698. Mountain, R. D., **Comments on fluctuation theory calculations of the specific heat near the critical point,** *J. Chem. Phys.* **52,** No. 7, 3852-3853 (April 1, 1970).

Key words: Cell model; correlation functions of fluids in the critical region; critical phenomena; distribution function; fluctuations in density; specific heat.

The failure of cell model calculations to correctly predict the critical region specific heat anomaly of a fluid is examined. The Gaussian assumption common to these calculations is seen to be the reason for the failure.

11699. Mountain, R. D., **Liquids: Dynamics of liquid structure,** *Critical Reviews in Solid State Sciences* **1,** No. 1, 5-46 (Chemical Rubber Co., Cleveland, Ohio, March 1970).

Key words: Infrared absorption; light scattering; liquids; magnetic resonance; molecular dynamics; neutron scattering; orientational correlation function; time correlation function.

The time correlation function formalism is used to bring out the interrelations existing for the experimental techniques of ultrasonic absorption, light scattering, neutron scattering, infrared absorption, dielectric absorption, magnetic resonance and molecular dynamics calculations. The dynamical effects in liquids associated with translational and rotational degrees of freedom are examined.

11700. Olver, F. W. J., **Why steepest descents?,** *SIAM Rev.* **12,** No. 2, 228-247 (April 19, 1970).

Key words: Airy integral; asymptotics; error bounds; gamma function; saddle-points; steepest descents; Watson's lemma.

A theorem is proved concerning the asymptotic expansion of contour integrals of the form

$$\int_a^b e^{-zp(t)}q(t)\,dt$$

in which $p(t)$ and $q(t)$ are analytic functions of t, and z is a large complex parameter. In comparison with the method of steepest descents, the essential condition imposed on the integration path by the new theorem is simply that $\operatorname{Re}\{zp(t)\}$ attains its minimum at one of the endpoints. The theorem is illustrated by application to the Airy function of large complex argument.

Methods are given for the calculation of realistic bounds for the error terms in the asymptotic expansion. In this analysis the use of paths of steepest descent is necessary, at least in the neighborhood of the minimum of $\operatorname{Re}\{zp(t)\}$. The error analysis is illustrated by some new results concerning Stirling's series.

11701. Osgood, C. F., **A method in diophantine approximation (III),** *Acta Arith.* **XVI,** 5-22 (1969).

Key words: Algebraic numbers; convolution product; differential equation; diophantine approximation.

In this paper the class of functions discussed in part II is investigated further. After introducing several normalizing conditions, it is shown to be a module under convolution multiplication from a certain ring of functions. Also algebraic coefficients and algebraic points can now be handled in our original type of differential equation.

11702. Osgood, C. F., **A method in diophantine approximation (IV),** *Acta Arith.* **XVI,** 23-40 (1969).

Key words: Convolution product; differential equations; diophantine approximation; irrational numbers; n-complex variables; rational numbers.

This paper generalizes the results in part III of this series of papers to $n > 1$ complex variables. It is shown that the values of a certain class of functions of n variables are poorly approximable at rational points in an appropriate domain. The algebraic structure of this class of functions is studied in an effort to determine the composition of the class. A module structure is exhibited under convolution product, i.e.

$$g_1(z_1,\ldots,z_n)*_k g_2(z_1,\ldots,z_n)=\int_0^{z_k}$$

$$g_1(z_1,\ldots,z_{k-1},t_k,z_{k+1},\ldots,z_n)$$

$$g_2(z_1,\ldots,z_{k-1},z_k-t_k,z_{k+1},\ldots,z_n)\partial t.$$

11703. Parke, W. C., Ponzini, R. G., Williams, H. T., **Remarks on finite-energy sum rules,** *Phys. Rev.* **1,** No. 1-D, 134-138 (Jan. 1, 1970).

Key words: Charge exchange; dispersion relations; duality; elementary particles; FESR; high energy scattering; pion-nucleon scattering; Regge parameters; sum rules.

Finite-energy sum rules with generalized weight functions are discussed with emphasis on methods for obtaining precise determination of high-energy parameters from low-energy data. Regge parameters for $t = 0$ πN charge-exchange amplitudes are deduced as an example from a new sum rule.

11704. Paulsen, P. J., Alvarez, R., Mueller, C. W., **Spark source mass spectrographic analysis of ingot iron for silver, copper, molybdenum, and nickel by isotope dilution and for cobalt by an internal standard technique,** *Anal. Chem.* **42,** 673-675 (May 1970).

Key words: Ingot iron; isotope dilution; NBS standard reference material; preconcentration; spark source mass spectrometry; trace element.

Isotope dilution procedures using the spark source mass spectrograph have proven reliable for simultaneous trace element determinations in high-purity metals. The objective of this study was to extend the applicability of this method for determining trace and minor elements in a relatively impure matrix, ingot iron.

In the method developed, isotopically enriched spikes of Ag, Cu, Mo, and Ni were added to 100-mg samples being dissolved; and a known amount of mononuclidic Co was added to half of the samples. After extracting the iron with isopropyl ether, the elements in the aqueous layer were electrodeposited onto gold wire electrodes for sparking in the mass spectrograph. The Ag, Cu, Mo, and Ni concentrations were calculated after determining the altered isotope ratios for all samples. By using Ni as an internal standard and the known additions of Co, the Co concentration was obtained by measuring the Co to Ni ratios for each of the samples. Concentrations ranged from 0.0050% for Ag to 0.025% for Ni.

11705. Qureshi, I. H., McClendon, L. T., LaFleur, P. D., **Extraction studies of the group IIIB-VIIB elements and the lanthanides utilizing bis(2-ethyl-hexyl) orthophosphoric acid,** *Radiochim. Acta* **12,** No. 2, 107-111 (Aug. 1969).

Key words: Group VIII; HDEHP; hydrochloric acid; IB and IIB elements; nitric acid; perchloric acid; solvent extraction.

The extraction behavior of the group IIIB-VIIB elements and the lanthanides from 1-11*M* hydrochloric, perchloric and nitric acid solutions into 0.75*M* bis(2-ethyl-hexyl) phosphoric acid solution has been studied. The group IVB elements and scandium exhibit high extraction which is independent of hydrogen ion concentration; the group VIIB elements are essentially unextracted. The extraction of some elements of group VB and VIB and of the lanthanides reaches a minimum and the increases with increasing acidity. This behavior is attributed to a change in extraction mechanism.

11706. Randall, E. B., Jr., Lashof, T. W., **An interlaboratory study of the measurement of the bursting strength of paper,** *Tappi* **53,** No. 5, 799-809 (May 1970).

Key words: Analysis of variance; analyzing; bursting strength; burst testers; comparisons; evaluation; foil paper; instrument characteristics; materials testing; measuring instruments; mechanical properties; mechanical testing; paper; precision; reliability; reproducibility; standards; testing; testing equipment.

This paper reports on the results of an extensive interlaboratory study, involving more than 175 laboratories in North America and overseas using several different models of bursting strength testers to evaluate 34 papers and 6 foils. Significant differences, both in a statistical and in an economic sense, were found between results obtained on different models and those in different laboratories using the same model, confirming previous reports. There were also significant day-to-day variations within a laboratory, and aluminum foil specimens gave results relative to those of paper specimens that depended on the instrument model used. A convenient rule for the number of replications was obtained from the study: make 10 replications unless the range of the first 10 is greater than 20% of their average, then make an additional 10. Two test results, each with 10 or 20 replications, are expected to agree with each other within the following values 95% of the time: 5.4% for repeatability within a laboratory, 9.5% for comparability between materials, and 14.3% for reproducibility between laboratories. Between-laboratory comparisons may be standardized through the use of a composite reference material of paper, aluminum foils being of only marginal use for this standardization.

11707. Raveché, H. J., Mayer, J. E., **Theory of diffusion in simple liquid mixtures,** *J. Chem. Phys.* **52,** No. 8, 3990-4004 (April 15, 1970).

Key words: Binary liquid mixture; closure condition; diffusion coefficient; distribution function; liquids; reduced Liouville equations.

A method is presented for obtaining the diffusion coefficient in terms of functions of molecular properties for a liquid system of monatomic molecules near equilibrium. The approach considers the reduced probability density functions $W_n(\mathbf{r}_1 \cdots \mathbf{p}_n)$ for n molecules ($n = 1$, 2, and 3) in the limit of a steady state. By operating on the complete probability density function W_N with the conventional Liouville operator and by integrating over the phase space of $N-n$ molecules, we write the time dependence of W_n in a form not explicity involving W_m for $m > n$. The reduced probability densities and the average vector forces are developed as a power series in a small parameter λ. Starting with singlet functions corresponding to a gradient in the density of a binary isothermal solution at constant pressure and the corresponding flux of molecules, we determine a singlet momentum-dependent force which maintains the flux and gradient stationary in time. The force can only be consistent with a certain class of pair probability functions, and we write the required general forms. Repeating the operation, we compute the average pair force which maintains the fluid in a steady state. The operation may, in principle, be carried to W_{n+1} for any n. From symmetry requirements we obtain a correction to the Kirkwood closure for the nonequilibrium factors in the triplet probability density. The closure fixes the ratio between the assumed density gradient and flux, which leads to the diffusion coefficient in terms of functions of pairs and triples of molecules and the intermolecular potential energy.

11708. Rosenblatt, J. R., Joiner, B. L., Hogben, D., **OMNITAB—Rapid statistical manipulation,** (Proc. Conf. Small-Area Statistics, American Statistical Association, New York, N.Y., Aug. 21, 1969), Paper in *Census Tract Papers Final 1970 Census Plans and Four Programming Systems for Computerized Data Retrieval and Manipulation, Series GE-40,* No. 6, pp. 46-59 (Superintendent of Documents, Government Printing Office, Washington, D.C., 20402, 65 cents, 1970).

Key words: Accuracy of computation; computing for non-programmers; computing system; data analysis; least squares computation; OMNITAB computing system; statistical computation; table making.

The nature of the OMNITAB computing system is illustrated and discussed, using several simple but realistic examples.

11709. Ryan, J. V., **Implementation of the Flammable Fabrics Act,** *Proc. Conf. Flame Retardant Cotton Batting Workshop, New Orleans, Louisiana, Nov. 15, 1968,* **ARS 72-72,** 1-77 (Oct. 1969).

Key words: Bedding; fabrics; flammability; hazards; mattresses; test methods; upholstered furniture.

Progress toward implementing the various provisions of the act will be described, along with the related problems. Ease of ignition, flame spread, transfer of heat, and development of smoke and other products of combustion are hazards, but not all apply to every product and use. New flammability standards will be based on risk to the public. Published procedures assure ample opportunity for all interested parties to participate in the development of standards. Most standards are expected to be for products, with industry free to choose fabrics and related materials to meet the requirements.

11710. Shipp, W. E., **Surface tension of binary mixtures of several organic liquids at 25 °C,** *J. Chem. Eng. Data* **15,** No. 2, 308-311 (April 1970).

Key words: Binary mixtures; density; organic liquids; surface tension.

The surface tension was determined for the following pairs of organic liquid mixtures over the entire range of concentration by the differential capillary rise method: benzene and ethyl acetate, carbon tetrachloride and ethyl acetate, benzene and carbon bisulfide, carbon tetrachloride and carbon bisulfide, benzene and carbon tetrachloride, and benzene and acetone. The first four pairs showed negative deviation and the last two, positive deviation from the ideal mixture relationship. The density of the first three pairs was also measured. Both surface tension and density were measured at 25 °C.

11711. Smith, S. J., **Survey on electron-atom collision experiments,** (Proc. Sommerfeld Centennial Memorial Meeting, Munich, Germany, Sept. 9-14, 1968), Chapter in *Physics of the One- and Two-Electron Atoms,* F. Bopp and H. Kleinpoppen, eds., pp. 574-597 (North Holland Publ. Co., Amsterdam, The Netherlands, 1969).

Key words: Atom; collisions; electron; helium; hydrogen; survey.

Within the last decade, application of the high-vacuum crossed-beam method to low energy collisions of electrons with hydrogen atoms has provided data on elastic, inelastic, and ionizing collisions. The experimental data appear to be largely internally consistent and to provide quite useful comparisons with theoretical results.

In helium, experimental elastic scattering and ionization data appears to be in a reasonable state, but the data on inelastic collisions are generally unsatisfactory. Opportunities for improvement through improved technique are noted.

11712. Vicentini-Missoni, M., Joseph, R. I., Green, M. S., Sengers, J. M. H. L., **Scaled equation of state and critical exponents in magnets and fluids,** *Phys. Rev. B.* **1,** No. 5, 2312-2331 (March 1, 1970).

Key words: Critical exponents; critical point fluids; Curie point; equation of state; ferromagnets; scaling laws.

A systematic analysis in the context of the scaled equation of state has been made of available experimental data in the critical region of a number of ferromagnets [Gd, $CrBr_3$, $La_{0.5}Sr_{0.5}CoO_3$, Ni (two independent sets of data)] and fluids (CO_2, He^4, Xe) with the following assumed form for $h(x)=HM^1|M|^{1-\delta}$:

$$h(x)=E_1[(x+x_0)/x_0]\{1+E_2[(x+x_0]/x_0]^{2\beta}\}^{[\beta(\delta-1)-1]/2\beta},$$

where $h(x)$ is a scaling function, $x=t|M|^{-1/\beta}$, $t=(T-T_c)/T_c$, and $x=-x_0$ is the phase boundary. A nonlinear, least-squares method was used to simultaneously determine the six parameters (β, δ, T_c, x_0, E_1, E_2). Agreement between the proposed form for $h(x)$ and the experimental data was found. For both the magnets and fluids, we find that $\delta\approx 4.4$; for the magnets $\beta\approx 0.37$ and for the fluids $\beta\approx 0.35$. Reasons for the considerably different values reported elsewhere for these exponents in the materials CrO_2 and $YFeO_3$ are discussed.

11713. Weisman, H. M., **In the beginning was the word—Information needs and uses in science and technology,** Paper E4-2 in *Proceedings of the Seventeenth International Technical Communications Conference, Minneapolis, Minn., June 3-6, 1970,* B. F. Hylen and R. R. McDaniel, eds., pp. 1-5 (Society of Technical Writers and Publishers Inc., 1010 Vermont Ave., N.W., Washington, D.C., 20005, 1970).

Key words: Information; "information explosion"; information producer; information user; knowledge; scientific literature; word.

This paper traces the role of the Scientific Literature in the progress of Science and Technology. It notes the effect of the "information explosion," and poses a challenge to the Technical Writer and Editor on the part they might play in meeting the information problem.

11714. Yakowitz, H., **Comments on "application of color photography to electron microbeam probe samples,"** *Rev. Sci. Instr.* **41,** No. 4, 601 (April 1970).

Key words: Color metallography; electron microprobe scanning; electron microscopy.

11715. Zielinzki, W. L., Jr., Freeman, D. H., Martire, D. E., Chow, L. C., **Gas chromatography and thermodynamics of divinylbenzene separations on 4,4′-dihexoxyazoxybenzene liquid crystal,** *Anal. Chem.* **42,** No. 2, 176-180 (February 1970).

Key words: Chromatography; gas chromatography; gas liquid; nematic liquid.

Gas-liquid chromatography in the nematic region of 4-4′-dihexoxyazoxybenzene liquid crystal has shown base-line separations for the meta and para isomers of divinylbenzene and ethylvinylbenzene. Thermodynamic treatment of the data has illustrated that the meta isomers have a lower solubility (resulting in shorter retention times) than the respective para derivatives owing to a greater enthalpic requirement for solution in the rod-like ordered solvent. The para/meta separation factors depict a greater rate of decrease with increasing column temperature in the isotropic liquid region because of the loss of order which is present in the anisotropic nematic region. Data for naphthalene present as a contaminant in divinylbenzene samples, were included in the treatment. Chromatographic extension to preparative scale appears feasible.

11716. Anderson, R. L., Guildner, L. A., Edsinger, R. E., **Movable and fixed modular vacuum devices with confined fluorocarbon plastic seals,** *Rev. Sci. Instr.* **41,** No. 7, 1076-1082 (July 1970).

Key words: Fluorocarbon bearings; fluorocarbon gaskets; modular vacuum components; vacuum ball joints; vacuum cylinder joints; vacuum seals; vacuum techniques; vacuum valves.

Sealing techniques have been perfected which utilize the properties of fluorocarbon plastics to make high vacuum seals. Several designs are described in which confined gaskets are used instead of O-rings, with consequent reduction of contamination from outgassing and permeation. These sealing techniques have been incorporated into a series of modular components which may be used for assembly of high vacuum systems. Some of these components are movable joints which allow leak-free motion between parts of a system. While not suited for high temperature bakeout, systems constructed from these modular components are capable of being pumped below 10^{-7} Torr. Dependable systems can easily be assembled or modified using these components, with no detectable helium leaks at a level of 2×10^{-10} std cm^3/sec.

11717. Arenhövel, H., Danos, M., Williams, H. T., **Baryon resonances in nuclei: Magnetic moments of the deuteron,** *Physics Letters* **31B,** No. 3, 109-112 (February 2, 1970).

Key words: Baryon resonances; deuteron; exchange currents; magnetic moments; nuclear structure; photodisintegration.

Baryon resonance admixtures to the p-n system have been calculated, as well as their effect on the static and transition magnetic moments of the deuteron.

11718. Arp, V., **Heat transport through helium II,** *Cryogenics* **10,** No. 2, 96-105 (April 1970).

> Key words: Helium II, superfluid; thermal conductivity; thermal gradient; thermal flux; turbulence; two-fluid hydrodynamics; vorticity.

Heat transport through He II is summarized in terms of the hydrodynamics of the two-fluid model. With increasing thermal flux, three regimes are identified, depending on the development of vorticity in the superfluid component and the development of a classical turbulence in the normal component. Calculation of summary curves of thermal gradient as a function of thermal flux is explained, and graphical results presented. An estimate of the limiting thermal flux for inception of vapor formation within He II is made, and time-dependent effects are discussed. The presentation is oriented towards use of He II in the nominal range from 1.5 to 2.1 K; special effects near the λ-point (2.17 K) are not considered, nor are conductivity changes below about 0.6 K due to rapid decreases of roton contributions.

11719. Berger, M. J., **Spectrum of energy deposited electrons in spherical regions,** *Proc. 2nd Symp. Microdosimetry, Stresa, Italy, Oct. 20-24, 1969,* Euratom Document No. 4452 d-f-e, pp. 541-559 (1970).

> Key words: Electrons; energy deposition, microdosimetry; Monte Carlo; multiple scattering; transport calculations.

Exploratory Monte Carlo calculations of electron transport in water have been made which are pertinent to microdosimetry. The objective of these calculations was to determine energy deposition spectra in spherical regions, i.e., the statistical distribution of the amounts of energy deposited as the result of the passage of electrons. Calculations were made for electrons with ranges comparable in magnitude to the size of the regions traversed, and the treatment therefore had to include certain phenomena that have been disregarded in previous microdosimetry calculations. These phenomena included (a) pathlength fluctuations and detours caused by multiple elastic scattering; (b) repeated passages of the same electron through the region as the result of backscattering; (c) the transport of energy into and out of the region of secondary knock-on electrons; and (d) the contributions to the energy deposition spectra from electrons born inside the region. Numerical results are presented for electrons with an initial energy of 5 keV that deposit their energy in spherical regions with diameters of 0.2 and 1.0 microns.

11720. Berger, M. J., Seltzer, S. M., Maeda, K., **Energy deposition by auroral electrons in the atmosphere,** *J. Atmospheric Terrest. Phys.* 32, 1015-1045 (1970).

> Key words: Atmosphere; aurora; electron; energy deposition; Monte Carlo; radiation transport.

The spatial distribution of the energy deposited by electrons in the atmosphere has been calculated by the Monte Carlo method. The distribution has been obtained as a function of the altitude and of the radial distance from the axis of the incident electron beam. The calculations take into account the deflection of the electrons by the geomagnetic field, and the scattering and slowing down due to multiple Coulomb interactions with atomic nuclei and orbital electrons. The assumed conditions were: (1) a semi-infinite air medium, extending downwards from a height of 300 km, with a composition and density corresponding to that of the CIRA (1965) Mean Atmosphere; (2) a vertical magnetic field with a strength of 0.6 G; (3) monoenergetic incident electron beams that are symmetric about a chosen field line; (4) incident electron energies between 20 keV and 2 keV; (5) various incident pitch-angles between 0° and 90°, or a pitch-angle distribution corresponding to an incident flux isotropic over the downward hemisphere. Calculations made with the same program, for a constant-density medium and no magnetic field, give good agreement with the results of laboratory experiments. The calculations are also in agreement with recent observations on an artificial aurora produced in the atmosphere with 8.7-keV electrons.

11721. Braun, W., Bass, A. M., Pilling, M., **Flash photolysis of ketene and diazomethane: The production and reaction kinetics of triplet and singlet methylene,** *J. Chem. Phys.* **52,** No. 10, 5131-5143 (May 15, 1970).

> Key words: Absolute reaction rates; diazomethane; flash photolysis; ketene; kinetics; methylene CH_2; vacuum UV.

Ketene and diazomethane have been flash photolyzed in their strongest absorption continua in the vacuum ultraviolet and far ultraviolet. Triplet methylene was monitored by kinetic spectroscopy at 141.5 nm. Singlet methylene was not observed directly, but the growth of the triplet absorption as a function of inert-gas pressure indicates that singlet methylene was the major primary product in both the ketene and diazomethane systems. Various inert additives quantitatively quenched the singlet to the triplet state, while reactive additives were able to intercept the singlet before quenching occurred. A number of reactions and deactivations involving singlet methylene ($^1CH_2$) and triplet methylene ($^3CH_2$) have been investigated at 298 K, and their rate constants are listed below (cm^3 molecule$\cdot^{-1}$ second^{-1}):

$$^3CH_2 + {}^3CH_2 \rightarrow C_2H_2 + n\,H_2 \quad (5.3 \pm 1.5) \times 10^{-11} \quad (1a), (1b)$$

$$^1CH_2 + H_2 \rightarrow CH_4^* \rightarrow CH_3 + H \quad (7.0 \pm 1.5) \times 10^{-12} \quad (2)$$

$$^1CH_2 + H_2 \rightarrow {}^3CH_2 + H_2 \quad < 1.5 \times 10^{-12} \quad (3)$$

$$^1CH_2 + CH_4 \rightarrow C_2H_6^* \rightarrow CH_3 + CH_3 \quad (1.9 \pm 0.5) \times 10^{-12} \quad (4)$$

$$^1CH_2 + CH_4 \rightarrow {}^3CH_2 + CH_4 \quad (1.6 \pm 0.5) \times 10^{-12} \quad (5)$$

$$^1CH_2 + He \rightarrow {}^3CH_2 + He \quad (3.0 \pm 0.7) \times 10^{-13} \quad (11)$$

$$^1CH_2 + Ar \rightarrow {}^3CH_2 + Ar \quad (6.7 \pm 1.3) \times 10^{-13} \quad (12)$$

$$^1CH_2 + N_2 \rightarrow {}^3CH_2 + N_2 \quad (9.0 \pm 2.0) \times 10^{-13} \quad (13)$$

$$^3CH_2 + H_2 \rightarrow CH_3 + H \quad < 5 \times 10^{-14} \quad (18)$$

$$^3CH_2 + CH_4 \rightarrow CH_3 + CH_3 \quad < 5 \times 10^{-14}. \quad (19)$$

The absolute reaction rates for the singlet are apparently independent of the source (i.e., ketene or diazomethane), suggesting that the reactions occur via vibrationally cold singlet methylene. No evidence was found for deactivation of the triplet to the singlet, indicating that the energy difference between the two states is greater than kT ($T = 298$ K).

11722. Bridges, J. M., Wiese, W. L., **The oscillator-strength scale for Fe I,** *Astrophys. J.* **161,** L71-L75 (July 1970).

> Key words: Arc; iron; oscillator strengths; spectrum; transition probabilities.

Extensive measurements of *f*-values for about 80 Fe I lines have been performed photoelectrically with a wall-stabilized arc at electron densities of about 10^{16} cm^{-3} and temperatures near 10000 K. Our measurements include the majority of those lines which have been recently investigated in a number of smaller, as yet unrelated experiments. All these measurements are thus tied together for the first time, and it is found that they generally agree with each other within a factor of 2 or better. On the other hand, our measurements indicate very definitely a strong dependence on upper excitation potential in the widely used data of

Corliss and co-workers. While there is good agreement with their data for lines of low excitation potentials, the deviations become as large as factors of 25 for lines starting from higher excitation potentials.

11723. Brower, W. S., Jr., Fang, P. H., **Dielectric constants of zinc tungstate,** *J. Appl. Phys.* **41,** No. 5, 2266 (April 1970).

Key words: Dielectric constant; single crystal; zinc tungstate.

The dielectric constants (ϵ') of zinc tungstate were measured at 24.5 °C in air. The averages and deviations from the mean of the three determinations for each orientation are as follows:

	a	b	c
ϵ'	17.2 ± 0.2	20.6 ± 0.3	$16.8 + 0.1$

11724. Brower, W. S., Jr., Fang, P. H., **Dielectric constants of scheelite structure crystals,** *J. Appl. Phys.* **40,** No. 12, 4988-4989 (November 1969).

Key words: Barium tungstate; dielectric constant; single crystal; strontium molybdate; strontium tungstate.

The dielectric constants (ϵ') of $SrMoO_4$, $SrWO_4$, and $BaWO_4$ were measured at 24.5 °C in air. The averages, and deviations from the mean, of two determinations are:

$SrMoO_4$	$\epsilon' \| a = 31.7 \pm 0.2$	$\epsilon' \| c = 41.7 \pm 0.2$
$SrWO_4$	$\epsilon' \| a = 25.7 \pm 0.2$	$\epsilon' \| c = 34.1 \pm 0.2$
$BaWO_4$	$\epsilon' \| a = 35.5 \pm 0.2$	$\epsilon' \| c = 37.2 \pm 0.2.$

11725. Brower, W. S., Jr., Farabaugh, E. N., **Dislocation etchant for single crystal Y_2O_3,** *J. Am. Ceram. Soc.* **53,** No. 4, 225 (April 1970).

Key words: Dislocations; etching; single crystal; Y_2O_3.

An etching technique has been developed to form dislocation etch pits on the {100} and {111} planes of single crystal Y_2O_3. Typical dislocation etch pit densities were of the order of 10^5 to $10^6/cm^2$.

11726. Cassidy, E. C., Cones, H. N., **Use of expanded laser beam to analyze high-intensity electric fields,** *J. Soc. Motion Picture Television Engrs.* **79,** No. 7, 590-591 (July 1970).

Key words: Dielectric liquids; electric field measurements; electro-optical measurements; high voltage measurements; Kerr cell; laser applications; pulse measurements.

A Kerr electro-optical technique that permits direct observation and mapping of distorted high-intensity electric fields has been devised at NBS. Analysis of the field profile from two-dimensional fringe images, similar to those observed in photoelastic mechanical stress analysis, permits calibration of the Kerr System for measurement of high-voltage pulses, and determination of relative field strength, actual field strength, and potential.

11727. Cezairliyan, A., **High-speed methods of measuring specific heat of electrical conductors at high temperatures (A review),** *High Temperatures—High Pressures* **1,** 517-529 (1969).

Key words: High-speed measurements; high temperature; specific heat; thermodynamics; thermophysical properties.

Needs and advantages of high-speed methods (subsecond duration) for the measurement of specific heat of electrical conductors at high temperatures are presented. The high-speed methods are described and classified according to ambient and operational conditions. Measurement and recording of experimental quantities are discussed. A historical development and the major features of high-speed experiments are summarized. A discussion and conclusions regarding the advantages of various high-speed methods and their applications are given.

11728. Chandler, R. F., Christian, R. A., **Crash testing of humans in automobile seats,** *Proc. Society of Automotive Engineers Safety Conf. May 13-15, 1970, Detroit, Mich., and June 8-11, 1970, Brussels, Belgium,* Intern. Safety Conf. Conpendium No. P-30, 112-132 (Society of Automotive Engineers, Inc., New York, N.Y., June 1970).

Key words: Anthropometric; automobile; crash; displacement; forces; human; impact; velocity.

The design of the automobile interior is largely based upon design data gathered under static conditions, where the inertial properties of the human body do not enter into consideration. Anthropometric data based on static measurements are valid for design of clearance and access for normal operation of the vehicle, and have been widely collected and used for these purposes. The requirements of the human operator or passenger during a crash are not as well documented. Clearances, paths of travel, velocities along the path and other dynamic data are of vital interest to the designer. Because of the difficulties in obtaining information about humans under crash conditions, most of the available guidelines are based upon dummy or cadaver tests. Until adequate human data are available, the designer must use the information obtained from human simulators and consider it only an unconfirmed approximation.

To alleviate this shortage of human impact data, the National Bureau of Standards initiated a research program in cooperation with the 6571st Aeromedical Research Laboratory. Tests were conducted on the Daisy Decelerator at Holloman AFB to gather comparative data about human and dummy test subjects under crash conditions using automotive seating and restraint systems. The data presented in this report include 32 human tests of controlled impacts of approximately the same magnitude. Variables are the type of restraint, either lap belt or lap belt plus single diagonal, and subject size. All tests were conducted in the $-Gx$ orientation using a production automobile bucket seat. Data presented include the displacement paths of the subjects during the impact, the maximum velocity along the path, anthropometric data, loads generated in the restraint system, and medical and subjective evaluation of the impacts.

11729. Childs, G. E., Diller, D. E., **Refractive index of liquid deuterium,** (Proc. 1969 Cryogenic Engineering Conf., June 16-18, 1969, Univ. of California, Los Angeles, Calif.), Chapter in *Advances in Cryogenic Engineering* **15,** Paper No. C-2, 65-69 (Plenum Press, Inc., New York, N.Y., 1970).

Key words: Deuterium; polarizability; refractive index; specific refraction.

The refractive index of liquid deuterium is often required for the analysis of data obtained from high-energy physics experiments which use bubble chambers containing this liquid as a radiating medium. Until recently no measurements of the refractive index of liquid deuterium had been published. Ayers et al. have recently determined a single value for the refractive index of the saturated liquid at 24.2 K at a radiation wavelength of 3200 Å. This paper describes a method which can be used to compute accurate refractive index values for deuterium throughout a wide range of temperatures, densities, and wavelengths. A few representative values of the refractive index of saturated liquid deuterium are presented for illustration.

11730. Christensen, R. G., Hoeve, C. A. J., **Comparison between theoretical and experimental values of the volume changes accompanying rubber extension,** *J. Polymer Sci.* **8,** Part A-1, 1503-1512 (1970).

Key words: Free energy; molecular theory; rubber elasticity.

The molecular theory of rubber elasticity assumes the free energy to consist of two parts: a liquidlike free energy that is governed by intermolecular interactions and is independent of strain at constant volume and an intramolecular interaction free energy equal to the sum of the free energies of the chains making up the network. The volume increases of rubber samples as a function of their length were found to be considerably larger than predicted by the molecular theory. Therefore, contrary to common belief, the values of $(\partial E/\partial L)_{V,T}$ might not be related solely to changes in intramolecular interactions with extension. Also, the usual procedure to obtain values of $(\partial E/\partial L)_{V,T}$ from measurements of $(\partial f/\partial T)_{p,L}$ with the aid of the molecular theory is not correct.

11731. Clark, A. F., Childs, G. E., Wallace, G. H., **Low-temperature electrical resistivity of some engineering alloys,** (Proc. 1969 Cryogenic Engineering Conf., June 16-18, 1969, Univ. of California, Los Angeles, Calif.), Chapter in *Advances in Cryogenic Engineering* **15,** Paper No. C-5, 85-90 (Plenum Press, Inc., New York, N.Y., 1970).

Key words: Aluminum alloys; copper alloys; electrical resistivity; iron alloys; nickel alloys; titanium alloys.

The electrical resistivities of several engineering alloys have been measured at 4K, 20K, 76K, 192K, and 273K. Different iron, nickel, copper, titanium and aluminum alloys have been measured, some of them in different heat treated conditions. Most of the alloys have a smooth decrease in resistivity with decreasing temperatures, but some unusual results are reported. Comparisons are made between different alloys and between different heat treatments of the same alloys.

11732. Coxon, B., **Model parameters for the analysis of skew conformations of carbohydrates by p.m.r. spectroscopy,** *Carbohydrate Res.* **13,** 321-330 (1970).

Key words: Carbohydrates; conformations; coupling constants; proton resonance; ribopyranose; skew.

The p.m.r. spectrum of 3-*O*-benzoyl-1,2,4-*O*-benzylidyne-α-D-ribopyranose (1) at 100 MHz has been analyzed by an iterative, least-squares method. The resulting geminal, vicinal, and long-range coupling-constants have been correlated with the stereochemistry of the locked, skew conformation of **1**, and used to test the applicability of equations that relate coupling constant to dihedral angle. The mean deviation of the approximate proton—proton dihedral angles as calculated from a Karplus equation from those measured from a molecular model was 11°.

11733. Daney, D. E., Rapial, A. S., **Preparation and characterization of slush hydrogen and nitrogen gels,** (Proc. 1969 Cryogenic Engineering Conf., June 16-18, 1969, Univ. of California, Los Angeles, Calif.), Chapter in *Advances in Cryogenic Engineering* **15,** Paper No. L-4, 467-475 (Plenum Press, Inc., New York, N.Y., 1970).

Key words: Gels, liquid hydrogen gels; liquid nitrogen gels; liquid-solid hydrogen mixtures; rocket propellants; slush hydrogen; slush hydrogen gels; slush nitrogen gels.

An experimental apparatus has been developed for the gelation of slush hydrogen, and slush hydrogen was gelled for the first time. Measurements of the weight-bearing capacity of the gel as a function of mass precent gelant were made for liquid and slush nitrogen and hydrogen. These measurements verify the simple models discussed here for gelled liquid and slush within the experimental accuracy; for the silica gelant used in this work the models predict a reduction in gelant concentration from 38 mass percent to 25 mass percent in going from Normal Boiling Point liquid hydrogen to slush hydrogen of 0.40 solid fraction. Reduction in the mass percent gelant for other gelants should be similar.

11734. Diller, D. E., Roder, H. M., **Thermal conductivity measurements on fluid hydrogen at 17 to 200 K and pressures to 10MN/m^2,** (Proc. 1969 Cryogenic Engineering Conf., June 16-18, 1969, Univ. of California, Los Angeles, Calif.), Chapter in *Advances in Cryogenic Engineering* **15,** Paper No. C-1, 58-64 (Plenum Press, Inc., New York, N.Y., 1970).

Key words: Critical region; parahydrogen; thermal conductivity.

New absolute thermal conductivity measurements on fluid normal and parahydrogen are reported. A nominal accuracy of 2% has been achieved using a parallel plate apparatus in the temperature range 17 to 200 K at pressures to 100 atm and densities to 2.6 times critical. A graphical presentation of the data is given along isotherms, isochores, and isobars in the following regions: (1) the dilute gas, (2) the moderately dense gas, (3) the saturated and compressed liquid, (4) the critical region. Several interesting features of the behavior of the thermal conductivity of this fluid are pointed out: (1) the thermal conductivity of saturated liquid hydrogen increases with temperature between the triple point and the normal boiling point in contrast to the temperature dependence for most liquids other than helium, (2) a large anomalous increase in the thermal conductivity of hydrogen was found in the vicinity of the critical point.

11735. Duncan, A. G., Hiza, M. J., **A multipurpose phase equilibrium apparatus to study mixtures of cryogenic fluids: Application to argon-methane,** (Proc. 1969 Cryogenic Engineering Conf., June 16-18, 1969, Univ. of California, Los Angeles, Calif.), Chapter in *Advances in Cryogenic Engineering* **15,** Paper No. B-2, 42-45 (Plenum Press, Inc., New York, N.Y., 1970).

Key words: Apparatus; argon-methane data; liquid-vapor; low temperature; phase equilibrium; solid-vapor; thermodynamic properties; three-phase loci.

A new phase equilibrium apparatus is described which is capable of providing data of sufficient accuracy for the derivation of meaningful thermodynamic properties of mixtures. It includes single-pass and recirculation flow options for measurement of solid-vapor and liquid-vapor equilibrium properties and the three-phase loci of mixtures from 10 to 150 K and up to 200 atm. Temperatures are measured with either a platinum or a germanium resistance thermometer, and phase compositions are determined by chromatographic or continuous analysis with appropriate detectors. Preliminary data for the Ar-CH_4 system are given as an example.

11736. Funkhouser, A. T., Mielenz, K. D., **High-speed holographic interferometry,** *Appl. Opt.* **9,** No. 5, 1215 (May 1970).

Key words: Holography; photography; ruby rod; solid-state laser rods.

A new method has been developed in which holographic interferometry and high-speed photography are combined to investigate rapid dynamic distortions. This method has been used for a time-resolved study of the distortions of solid-state laser rods which result from optical pumping. A ruby rod has been studied and convex distortions have been observed at several pumping levels.

11737. Gadzuk, J. W., **Resonance-tunneling spectroscopy of atoms adsorbed on metal surfaces: Theory,** *Phys. Rev. B.* **1,** No. 5, 2110-2129 (March 1, 1970).

Key words: Adsorption; atomic spectroscopy; electron tunneling; surface physics.

Using a perturbational approach, we consider the theory of resonance tunneling of field-emitted electrons through atoms adsorbed on metal surfaces, first treated by Duke and Alferieff. It is shown how one can proceed from the observed total energy distributions to information concerning the energy-level spectrum of the atom perturbed by the metal surface. The major alteration of the spectrum manifests itself in a shift and lifetime broadening of the atomic energy levels due to configuration interactions with the continuum of metal states. In past work, this shift and broadening have been theoretically calculated by various workers. Theories have also been advanced for calculating dipole moments and, consequently, work-function changes and binding energies in which the final expressions for these quantities require knowledge of the perturbed atomic energy-level scheme. The plan in the present paper is to present a method of analyzing the data obtained in resonance-tunneling spectroscopy so that values for the shift and broadening of the energy levels can be obtained. To proceed towards this end, a simplified model is treated in a mathematically systematic manner We believe, however, that the present approach maintains sufficiently close contact with the physics of the processes involved and thus, because of its transparency, is a potentially more valuable tool than past theories. The first experimental data of resonance tunneling in field emission, obtained by Plummer and Young and reported on in the preceding paper, are analyzed within the context of the present theory. These data include tunneling through single Zr atoms in which a single broad ground-state level is seen, tunneling through Ba atoms in which both a broad ground state of $6s^2$ character and two narrow excited $6s\ 5d$ states are seen, and tunneling through Ca in which a somewhat narrow $4s\ 4p$ excited state is seen. Most aspects of the data are satisfactorily accounted for in the present theory, and the observed shifts and broadenings of the levels are in good agreement with past calculations.

11738. Geil. G. W., Feinberg, I J., **Temperature changes in specimens in microplasticity tests,** *Met. Trans.* **1,** No. 7, 1845-1851 (July 1970).

Key words: Capacitance gages; invar; loading rate; microplasticity; strain measurement; temperature changes in tensile specimens; 4340 steel.

A tensile specimen and a gage assembly were designed to measure plastic strain at room temperature. The assembly mounts three capacitance strain gages 120 deg apart, and is held by ribs with a 45 deg included angle so as to define a 2 in. (5.08 cm) gage length. This novel construction eliminates spurious effects due to the fillets and shoulders of the specimen. The strain sensitivity is $\pm 1 \times 10^{-7}$. The cooling and heating of a specimen, accompanying the loading and unloading, respectively, in the elastic range, are shown to affect plastic strain readings in a manner not considered by other investigators of microplasticity. The thermal contributions to apparent strain in specimens of normalized 4340 steel and annealed Invar were determined and were found to be significant at strains less than 10^{-5}. Strain measurement techniques necessary for the exclusion of the thermal dimensional changes of the specimen from the measurement of very small plastic strains are discussed.

11739. Giacchetti, A., Stanley, R. W., Zalubas, R., **Proposed secondary-standard wavelengths in the spectrum of thorium,** *J. Opt. Soc. Am.* **69,** No. 4, 474-489 (April 1970).

Key words: Secondary standards in thorium spectrum; standards of wavelength; thorium; thorium standards of class B; wavelength standards.

Energy levels for Th I were computed from the weighted averages of wavelengths from seven sets of published interferometrically measured data. The most self-consistent energy levels obtained in this way were then employed to calculate wavenumbers that have a standard deviation of less than 10 mK. We propose that these lines be adopted as class-B secondary standards. Calculated wavelengths of 1375 Th I lines and weighted averages of 181 interferometrically measured Th I and Th II lines between 2565 and 12 381 Å are given.

11740. Gonano, J. R., Adams, E. D., ***In Situ* vapor pressure measurement for low temperature thermometry,** *Rev. Sci. Instr.* **41,** No. 5, 716-719 (May 1970).

Key words: Capacitance manometer; cryogenic thermometry; manometry; pressure measurement; thermomolecular pressure difference; vapor pressure; vapor pressure thermometry.

By use of a capacitance diaphragm manometer operated at low temperatures, it is possible to measure the vapor pressure of cryogenic liquids without the uncertainties introduced by thermomolecular pressure gradients (thermal transpiration). Since the zero of this manometer is more stable at low temperature than at room temperature, useful sensitivity is increased. Because of the increased sensitivity at low pressure as well as great convenience and simplicity this technique appears to have wide application in precise vapor pressure thermometry and similar work.

11741. Greenspan, M., Tschiegg, C. E., **Cavitation nucleated by ^{10}B(n,α)^{7}Li,** *Nucl. Instr. Methods* **82,** No. 3, 310-312 (1970).

Key words: Acoustic cavitation; boron (n,α) lithium reaction; cavitation; neutron detection; radiation-induced cavitation; thermal neutron detection.

Acoustic cavitation has been nucleated on the reaction ^{10}B(n,α)^{7}Li in methanol solution. Implications for a slow neutron detector or counter are discussed.

11742. Haar, L., Sengers, J. M. H. L., **The solubility of condensed substances in dense gases, and the effect on *PVT* properties,** *J. Chem. Phys.* **52,** No. 10, 5069-5079 (May 15, 1970).

Key words: Ammonia; dense gases; equation of state; hydrogen; mercury vapor; nitrogen; noble gases; solubility-enhancement; steam; van der Waals' equation.

An analytic relation is derived in terms of the molecular interactions for the density dependence of the solubility of a liquid or solid in dense gas using a modified van der Waals equation. It is shown that at high gas densities the solubility is sharply reduced. It is also shown that the effect of the solubility enhancement on high-density *PVT* measurements is smaller than previously thought. The analysis is applied to the case where the condensed material is liquid mercury. Solubility-vs-density isotherms and the effect of the solubility on *PVT* measurements are obtained at 50, 150, 250, and 400 °C for the following gaseous species: He, H_2, Ne, Ar, Kr, Xe, N_2, NH_3, H_2O. The need for accurate experimental data at high gas densities to test further the essential features of the analysis is discussed.

11743. Hamilton, W. C., Edmonds, J. W., Tippe, A., Rush, J. J., **Methyl group rotation and the low temperature transition in hexamethylbenzene. A neutron diffraction study,** *Discussions Faraday Soc.*, No. 48, 192-204 (1969).

Key words: Barrier to rotation; crystal; crystal structure; hexamethylbenzene; hindered rotation; phase transition; torsional oscillation; λ-point methyl group.

Neutron diffraction studies of single crystals of hexamethylbenzene at 298 K and at 130 K indicate that the molecule in e II has appromimate D_{3d} symmetry. The amplitudes of libration of the methyl group and of rigid body motions of the molecule are consistent with earlier data, except that the barrier to methyl group rotation appears to be lower by about 0.5 kcal/mol (2100 J/mol).

Consideration of intra- and inter-molecular hydrogen atom contact distances and calculated potential energy curves using a 6-exp potential function suggest that intermolecular forces are important in determining the barrier to rotation of the methyl groups and that substantial changes in the intermolecular packing must be responsible for the lambda-point transition at 116 K and the consequent profound change in the potential barrier to internal rotation which has been previously observed.

11744. Hanson, D. W., **Quasi-optical components using total reflection in dielectrics,** *IEEE Trans. Microwave Theory Tech.* **MTT-18,** No. 4, 233-234 (April 1970).

Key words: Millimeter waves; polarizers; quasi-optics; total relection; turnstile junction.

Two quasi-optical components operating at 90 GHz which use the effects of a metal plate on total reflection are described. A circular polarizer and, with the addition of a metal plate grating, a device having properties similar to a tuned turnstile junction were constructed. Experimental results showed better than 99 percent polarization conversion for the polarizer.

11745. Hendricks, R. C., Simoneau, R. J., Smith, R. V., **Survey of heat transfer to near-critical fluids,** (Proc. 1969 Cryogenic Engineering Conf., June 16-18, 1969, Univ. of California, Los Angeles, Calif.), Chapter in *Advances in Cryogenic Engineering* **15,** Paper No. G-1, 197-237 (Plenum Press, Inc., New York, N.Y., 1970).

Key words: Choking; critical; fluid; fluid flow; heat transfer; oscillations.

The three authors have reviewed the field and added some new material. The intent of the paper is to bring the literature together, to provide information for designers, and to suggest needed research.

11746. Heydemann, P. L., **Ultrasonic measurements at pressures up to 50 kbar,** *Proc. Intern. Collog. Solids at High Pressures, Grenoble, France, Sept. 8, 1969,* No. 188, pp. 461-467 (Centre National de la Recherche Scientifique, Paris, France, 1970).

Key words: Bulk modulus; equation of state; high pressure; phase transitions; potassium chloride; tellurium; ultrasonics.

Ultrasonic measurements as a function of pressure or temperature provide one of the most accurate means to determine pressure or temperature dependence of the bulk modulus and the density of both liquids and solids. Such measurements are currently carried out with very high accuracy at pressures up to about 4 kbar (1 kbar= 10^8N/m^2) in several laboratories.

If the material under investigation undergoes transitions at higher pressures, or if the bulk modulus is noticeably non-linear with pressure, ultrasonic measurements at pressures higher than 4 kbar are needed. This report describes our method to carry out such measurements at pressures close to 50 kbar, both under hydrostatic and non-hydrostatic conditions.

For most materials the accuracy of the density and bulk modulus data obtained from such measurements is much higher than that obtained from isothermal dilatometric measurements. In the case of tellurium, the accuracies for the bulk modulus at 30 kbar are 1.6% and 23%, respectively.

Another interesting application of ultrasonics at high pressures is the detection of phase transitions and the measurement of the elastic properties as the material undergoes the transition. As an example for measurements through a transition range, our results of ultrasonic and isothermal dilatometric measurements on KCl are presented. We find that the ratio of specific heats also shows a sharp increase in the transition range.

11747. Hiza, M. J., **Solid-vapor equilibria research on systems of interest in cryogenics,** *Cryogenics* **10,** No. 2, 106-115 (April 1970).

Key words: Combining rule correlation; cryogenic; enhancement factor theory; review; solid-vapor equilibria; vapor pressures.

A review of research associated with solid-vapor equilibria of cryogenic systems is given with emphasis on the fundamental value of such studies. Included are discussions of vapor pressures of solidified fluids, theory applicable to the prediction of solid-vapor equilibria, available data in the solid-vapor region for systems of cryogenic interest, and a correlation derived from selected solid-vapor equilibria data, which is offered as a significant improvement in the prediction of properties of two-component systems in general.

11748. Kidnay, A. J., Hiza, M. J., Dickson, P. F., **Adsorption kinetics in a ternary system containing hydrogen,** (Proc. 1969 Cryogenic Engineering Conf., June 16-18, 1969, Univ. of California, Los Angeles, Calif.), Chapter in *Advances in Cryogenic Engineering* **15,** Paper No. B-3, 46-49 (Plenum Press, Inc., New York, N.Y., 1970).

Key words: Adsorption; hydrogen; kinetics; methane; nitrogen; ternary system.

The concentration-time (breakthrough) curves for a ternary mixture of nitrogen, methane, and hydrogen were measured on an activated coconut shell charcoal at 76 K over a range of flow rates. The equations of Eagleton and Bliss were used to obtain gas phase and adsorbed phase mass transfer coefficients from the breakthrough curves. The values for the gas phase mass transfer coefficient, when converted to *j* values, are in fair agreement with the generalized correlations proposed by De Acetis and Thodos. The breakthrough curves were also correlated using the empirical method proposed by Engel and Coull, with good results.

11749. Lawton, R. A., **New standard of electric field strength,** *IEEE Trans. Instr. Meas.* **IM-19,** No. 1, 45-51 (Feb. 1970).

Key words: Antenna; electric field strength; measurement; standard field.

A new technique is presented for establishing a standard of electric field strength using a highly conducting sphere. An analysis is made to determine the current on the sphere as a function of the electric field strength of an incident plane wave. A method of measuring that current using electronic circuitry and an optical indicator within the sphere is described, and an intercomparison is made with an independent field-strength standard.

This technique is a significant improvement over previous ones in that it permits the absolute determination of field strength with a maximum uncertainty of 1 percent or less at 30 MHz and is applicable to a broad range of frequencies and field strengths.

11750. Levin, E. M., **X-ray determination of the thermal expansion of silver nitrate,** *J. Am. Ceram. Soc.* **52,** No. 1, 53-54 (January 1969).

Key words: $AgNO_3$; density $AgNo_3$; polymorphism $AgNO_3$; thermal expansion $AgNO_3$; unit cell dimensions $AgNO_3$.

An x-ray diffractometer furnace was used to obtain powder patterns of orthorhombic (low) $AgNO_3$ between 25° and 140 °C and of rhombohedral (high) $AgNO_3$ between 25° and 175 °C. Unit cell dimensions are given for selected temperatures and are essentially a linear function of temperature. The values for the coefficient of expansion of low $AgNo_3$ along *a*, *b*, and *c*, respectively, are 126×10^{-6} deg^{-1}, 57×10^{-6} deg^{-1}, -0.4×10^{-6} deg^{-1}. For high $AgNO_3$ the values along *a* and *c*, respectively, are 30×10^{-6} deg^{-1} and 134×10^{-6} deg^{-1}. X-ray density of the high form at a given temperature is greater than that of the low form and, in general, does not agree with previous reported results. The value of dT/dP calculated from the Clausius-Clapeyron equation is

-6.9×10^{-3} K/bar, at atmospheric pressure, vs Bridgman's experimental value of -7.6×10^{-3} K/bar.

11751. Lutz, G. J., Masters, L. W., **Determination of carbon in high purity metals by photon activation analysis,** *Anal. Chem.* **42,** No. 8, 948-950 (July 1970).

Key words: Carbon; combustion separations; metals; photon activation analysis; radiochemical separations.

Photon activation anlaysis has been applied to the determination of carbon in a variety of pure metals. The samples are irradiated in the bremsstrahlung beam produced from electrons accelerated to 35 MeV. The reaction $^{12}C(\gamma,n)^{11}C$ is induced at these energies. The product nucleus has a half-life of 20.5 minutes and decays by positron emission. The separation of carbon is based on traditional high temperature combustion methods. The intrinsic sensitivity for the production of ^{11}C, coupled with the absence of reagent and equipment blanks and the ability in some instances to etch the sample after irradiation but before separation and counting, allows determinations at levels below 10^{-7} grams of carbon. Precisions of 5-20 percent at levels of ppm or less are typical.

11752. Machta, L., Hughes, E., **Atmospheric oxygen in 1967-1970,** *Science* **168,** No. 3939, 1582-1584 (June 26, 1970).

Key words: Atmospheric composition; oxygen analysis; photosynthetic oxygen; oxygen variations.

Observations of atmospheric oxygen in clean air between 50 °N and 60 °S, mainly over the oceans, yield an almost constant value of 20.946 mole percent dry air. Since 1910 changes with time are either zero or smaller than the uncertainty in the measurements. Burning of fossil fuels since 1910 would have reduced the oxygen content by 0.005 mole percent while future combustion of all known recoverable fossil fuels could lower the oxygen content to about 20.8 mole percent.

11753. Madey, T. E., Yates, J. T., Jr., **Chemisorption on single crystals: H_2 on (100) tungsten,** *Proc. Colloque Intern. sur la Structure et les Proprietes des Surfaces des Solides, Paris, France, July 7-11, 1969,* No. 187, pp. 155-162 (Centre National de la Recherche Scientifique, Paris, France, 1970).

Key words: Binding state; chemisorption; hydrogen; isotopes; single crystal; tungsten; work function.

An ultrahigh vacuum apparatus has been constructed to study flash desorption of gaseous molecules from macroscopic single crystals. The crystals are in the form of thin discs, polished on both faces, whose total surface area is 95% of one orientation. A focussed light source external to the vacuum system is used to heat the nearly adiabatically suspended sample to $T > 1200$ K; temperature inhomogeneities and end effects which complicate kinetic measurements on resistively heated samples are not present here. The sample is cleaned by electron bombardment prior to making adsorption measurements. Work function changes upon adsorption are monitored using an electron gun; a quadrupole mass spectrometer is used as the detector of desorbed species.

The chemisorption of H_2 and D_2 on a (100) oriented tungsten disc has been examined with this apparatus. The hydrogen desorption spectra reveal that *two* binding states exist on the (100) surface. The first order β_1 state desorbs with an activation energy of ~25 kcal/mole and at saturation coverage, is twice as densely populated as the β_2 state. The coadsorption of an equimolar mixture of H_2 and D_2 shows that *both* states are isotopically mixed upon desorption. The work function-coverage relation is linear over the entire coverage range; the dipole moment per atom is 0.15 Debye, independent of binding state. Several models of H_2 chemisorption are discussed.

11754. Madey T. E., Yates, J. T., Jr., King, D. A., Uhlaner, C. J., **Isotope effect in electron stimulated desorption: oxygen chemisorbed on tungsten,** *J. Chem. Phys.* **52,** No. 10, 5215-5220 (May 15, 1970).

Key words: Adsorption; chemisorption; desorption; electron bombardment; isotope; oxygen; single crystal; tungsten.

Electron stimulated desorption (ESD) studies of oxygen chemisorbed on tungsten have revealed a large isotope effect in the desorption of ions. The probability of desorption of $^{16}O^+$ was found to be a factor of ~1.5 greater than the probability of desorption of $^{18}O^+$ upon bombardment of the adsorbed layer by 100-eV electrons. This observation is quantitatively consistent with the ESD mechanism proposed independently by Redhead and by Menzel and Gomer. On the other hand, the small isotope effect observed in ESD "total" desorption does not agree with this mechanism; possible reasons for this are discussed.

11755. Mahler, R. J., James L. W., **Acoustic and magnetic effects involving the ^{19}F nuclei in antiferromagnetic $KMnF_3$,** *J. Appl. Phys.* **41,** No. 4, 1633-1636 (March 15, 1970).

Key words: Interaction; nuclear spin system; phonons; transferred hyperfine.

A simple model which allows spin-1/2 nuclei in antiferromagnetic crystals to interact with phonons is presented and an order of magnitude calculation predicts the one- and two-phonon effects observed in $KMnF_3$.

11756. Margoshes, M., **Data acquistion and computation in spectrochemical analysis: A forecast,** *Spectrochim. Acta* **25B,** 113-122 (June 15, 1969).

Key words: Automation; computers; data acquisition; emission spectroscopy; microphotometers; spectrochemical analysis; television cameras.

Some new applications of automation and computerization in emission spectrochemical analysis are proposed. Automated microphotometers now make it possible to digitize complete photographically-recorded emission spectra in a reasonable time. Television techniques offer the prospect of digitally recording complete spectra photoelectrically, circumventing the problems and loss of time encountered with photographic spectroscopy. Reduction of the data with computers should make possible completely automatic qualitative analysis. Semiquantitative analysis without standards may also be possible. When standards are available, the use of computers for data reduction should improve the accuracy of analysis by allowing complex corrections to be made for interelement effects. The cost of programming could delay the development of these proposals, and a cooperative research program is suggested to reduce the cost to any one laboratory.

11757. Marvin, R. S., **Rheological models and measurements,** (Proc. 5th Intern. Congress on Rheology, Kyoto, Japan, Oct. 7-11, 1968), Chapter in *Fifth International Congress on Rheology,* S. Onogi, ed., 1, 85-96, (University of Tokyo Press and University Park Press, Tokyo, Japan, 1969).

Key words: Measurements; model; rheology.

The evaluation of the rheological properties of a material requires certain assumptions from which the form of a constitutive equation can be deduced. The term model, whether molecular or phenomenological, here denotes the body of assumptions used in the development of a particular theory. The testing of these assumptions and the evaluation of the constants or functions in the resulting constitutive equation require the design and performance of various measurements. A single type of measurement may be adequate to evaluate functions occurring in a constitutive equation, but it is seldom sufficient to establish the validity of the assumptions on which that equation is based. Such results may simply establish an equation as a good empirical representation, a useful accomplishment, but one quite different from establishing the validity or adequacy of a model.

In carrying out measurements intended to check a model or some of the assumptions on which a model is based, certain factors which are deliberately ignored in the model (always an idealization of an actual material) must be considered, as must the effect of deviations from boundary conditions assumed in the measurement. And, a consideration often ignored, both the measurement and the manner in which the results are analyzed should be chosen to provide a sensitive check of the assumption or model. The history of experiments stimulated by the Weissenberg hypothesis about the equality of normal stress differences illustrates both the difficulty of satisfying these criteria and the danger of judging the correctness of a hypothesis or a model from the results of a single type of measurement.

11758. Mauvais, C. J., Latanision, R. M., Ruff, A. W., Jr., **On the anisotropy observed during the passivation of nickel monocrystals,** *J. Electrochem. Soc.* **117,** No. 7, 902-903 (July 1970).

Key words: Dislocations; nickel-single crystals; passive film; polarization; surfaces.

Potentiostatic polarization measurements on the three low index faces of a nickel monocrystal in 1*N* H_2SO_4 indicate a strong anisotropy in the passive region. Specifically, the degree of protection provided by the passive film on a {111} surface is greater than on either {110} or {100} faces, an orientation dependence identical to that observed for epitaxial films produced during gaseous oxidation. This behavior is discussed in terms of the creation of misfit dislocations at the crystal-passive film interface and the effect of misfit boundaries in the film.

11759. McNish, A. G., **The impact of increasing metric usage,** *Proc. Conf. Industrial Heating Equipment Association, Spring (77th Consecutive) Meeting, Hot Springs, Virginia, May 19-21, 1969,* Exhibit E, 12 pages (Industrial Heating Equipment Assoc., Washington, D.C., 1969).

Key words: Metric system; metric usage; Public Law 90-472.

Public Law 90-472 requires the Secretary of Commerce to determine the advantages and disadvantages of increased use of the metric system in the United States. Subsequent to its passage, the Secretary assigned responsibility for the Study to the National Bureau of Standards.

Degrees of increased use may be designated as accommodation, involving translation of measurement units where frequent use of measurements is not involved; adaptation, involving dual labelling of packaged goods and dual dimensioning of mechanical items; and conversion, involving design of products in the metric system yielding a final product which is completely metric.

Metric products are often produced in nonmetric shops and vice-versa, but with increased costs and difficulties. Many U.S. industries already make extensive use of the metric system. Difficulties experienced in producing metric products in U.S. factories arise because metric standard parts and metric stock sizes are not readily available in the United States. This is a particular difficulty experienced by companies which operate plants in the United States and abroad, which in many cases, require different designs for economical production.

On the other hand, there are many industries where U.S. based standards have found worldwide use and acceptance and change for many of these standards is undesirable, though the sizes and dimensions of the products involved may someday be expressed in metric language.

11760. McNish, A. G., **Progress on the Metric Study Program,** *Proc. Conf. 18th Annual Meeting of Standards Engineers Society, Washington, D.C., Sept. 17-19, 1969,* pp. 53-56 (Standards Engineers Society, Philadelphia, Pa., 1969).

Key words: Cost of transition; industrial cooperation; metric system; trade advantages.

The Metric Study Program is progressing at such a rate that it seems that completion of the Study on schedule can be accomplished. Techniques for the evaluation of the costs of increased metric usage have been developed in cooperation with industry. If transition to the metric system takes place at an optimum rate, the costs will not be as great as many of the estimates that have been made in the past. The Study is receiving cooperation from other branches of the government with an outstanding effort from the Department of Defense in evaluation of the costs of any possible change and its impact on our military posture. No great immediate advantage to our export trade is suggested by the statistics presently available, although international operations would be considerably helped by use of a single system of measurement.

11761. Melmed, A. J., Carroll, J. J., **Ellipsometry, LEED, and FEM study of evaporated epitaxial films of iron on (011) tungsten,** *Surface Science Letters to the Editor* **19,** No. 1, 243-248 (January 1970).

Key words: Ellipsometry; epitaxy; index of refraction; optical constants; thin films vapor deposition.

The structure, thickness, and optical constants of iron films vapor-deposited onto a single-crystal (011) tungsten substrate in ultra-high vacuum have been characterized by the ELF (ellipsometry, LEED, FEM) apparatus developed at NBS. It is shown that films of thickness 400 Å or greater have (after annealing) optical properties and surface structure indistinguishable from bulk iron.

11762. Mighell, A. D., Reimann, C. W., Santoro, A., **The crystal structure of the 2:1 dimer [(pyridine *N*-oxide)$_2$CuBr$_2$]$_2$,** *Chem. Commun.* **4,** 204 (1970).

Key words: Crystal structure; pyridine *N*-oxide cupric bromide dimer.

The structure of the 2:1 dimer [(pyridine *N*-oxide)$_2$CuBr$_2$]$_2$ is reported and is shown to differ significantly from that of the corresponding chloride complex as well as from other structure types in the aromatic *N*-oxide series.

11763. Melino, J. A., **Noise—the growing hazard,** *Dialog* **1,** No. 4, 26-28 (1970).

Key words: Hearing conservation; noise abatement; noise pollution.

Noise is a growing hazard. The private and public sectors of the country have responded to the problem in concrete ways. Hopefully the widespread concern over noise will lead to a forceful national program of noise control. But young people have created a special problem with the harmful sound levels of rock music. The damaging intensities of this kind of music should be further investigated.

11764. Negas, T., Roth, R. S., **The system $SrMnO_{3-x}$,** *J. Solid State Chem.* **1,** 409-418 (1970).

Key words: Four-layer $SrMnO_3$; perovskites; phase equilibria; strontium manganates; tetravalent manganese; trivalent manganese.

The system $SrMnO_{3-x}$ ($0 \leqslant x \leqslant 0.5$) was investigated by gravimetric and quenching experiments. Four-layer, hexagonal $SrMnO_3$ ($a = 5.449$ Å, $c = 9.078$ Å) is stable in air below 1035 °C. Above 1035 °C the basic structure becomes increasingly anion deficient, reaching the limiting composition $SrMnO_{2.89}$ near 1400 °C. Unit cell dimensions increase and distortion to orthorhombic symmetry occurs with decreasing oxygen content. Further reduction occurs from 1400 °C to a melting point at 1740 °C and a "perovskite" homogeneity range exists with limits $SrMnO_{2.74}$ and $SrMnO_{2.62}$. The anion-deficient perovskite phases can be rapidly reoxidized at low temperatures to yield a metastable cubic perovskite, $SrMnO_3$ ($a = 3.806$ Å). Stoichiometry and stability of phases are discussed from the standpoint of variation in the coordination of the manganese cation.

11765. Page, C. H., **The trolley problem,** *Am. J. Phys.* **38,** No. 5, 608-610 (May 1970).

Key words: Current density; electric current; electromagnetic field; Lorentz transformation; sliding circuit.

A rectangular current circuit in which one conductor is moving along its own axis is Lorentz equivalent to a two-trolley loop sliding along a stationary wire. The body and surface densities of charge and current are deduced on the basis of a simplifying idealization.

11766. Page, C. H., **Relations among systems of electromagnetic equations,** *Am. J. Phys.* **38,** No. 4, 421-424 (April 1970).

Key words: Coherent; dimension; quantity; rationalization; systems of equations; units.

The equations of electromagnetism, whether written in the electrostatic, electromagnetic, or symmetric system, whether in rationalized or nonrationalized from, express an invariant set of physical relationships. The same set of letter symbols is employed in each system of equations; these symbols represent related, but different, quantities in the various systems. The relationships among corresponding symbols are given and applied to precise statements about the relation between the oersted and the ampere per meter, the abampere and the ampere, etc.

11767. Pfeiffer, E. R., Schooley, J. F., **Effect of stress on the superconducting transition temperature of $SrTiO_3$,** *J. Low Temp. Phys.* **2,** No. 3/4, 333-352 (August 7, 1970).

Key words: Anisotropic stress effect; hydrostatic pressure; Nb-doped $SrTiO_3$; reduced $SrTiO_3$; superconductivity; transition temperatures; uniaxial compression; 0-1.8 kbars stress.

The superconducting transition temperatures of several specimens of reduced $SrTiO_3$ and of Nb-doped $SrTiO_3$ have been investigated as functions of hydrostatic and uniaxial compressive stresses up to 1.8 kbars. Decreases in T_c as large as 0.12 K have been observed in specimens under hydrostatic pressure. Because of the low T_c and small compressibility of $SrTiO_3$, $\Delta(\ln T_c/\Delta P$ and $\Delta(\ln T_c)/\Delta(\ln V)$ are orders of magnitude greater than the corresponding effects in elemental superconductors. The effect of uniaxial stress on T_c varied with the direction of stress. Compression along a [111] direction caused large decreases in T_c, while both small increases and small decreases in T_c have been observed for [100] compression. It is believed that the present results reveal the presence of a sensitive volume dependence in one or more of the parameters important to superconductivity in $SrTiO_3$, and that no significant electron-transfer effects occurred in the range of stresses of this experiment.

11768. Phillips, S. L., Johnson, C. E., **Effect of atmospheric exposure on the contact resistance of selected tin alloys,** *J. Electrochem. Soc.* **117,** No. 6, 827-830 (June 1970).

Key words: Contact resistance; corrosion; metal plating.

Atmospheric exposure of plated specimens in a rural outdoor location showed that both tin-zinc and tin-cadmium alloy coatings on steel maintained a lower contact resistance than did equal thicknesses of tin, tin-lead, or tin-antimony alloys. After exposure for over 2 months, the contact resistances under a 50g load for 5-38 μm thicknesses of tin-zinc and tin-cadmium ranged between 10-100 mohms, although both coatings rapidly lost their luster. The tin-lead alloy maintained the lowest contact resistance of all the coatings tested, although it failed to provide corrosion protection as good as equal thicknesses of tin-zinc or tin-cadmium.

11769. Plummer, E. W., Young, R. D., **Field-emission studies of electronic energy levels of adsorbed atoms,** *Phys. Rev. B.* **1,** No. 5, 2088-2109 (March 1, 1970).

Key words: Adsorption; alkaline earths; atomic energy levels; surface; tungsten; tunneling resonance.

The relative changes in the total energy distribution of field-emitted electrons upon adsorption of single atoms have been measured for adsorption of the alkaline-earth atoms (Ba, Sr, and Ca) on several crystal planes of tungsten. The expected perturbations of the energy distribution due to the tunneling resonance through an atomic "virtual level" at various positions relative to the Fermi surface and of various half-widths Γ is demonstrated by a simple one-dimensional calculation. The measured energy-dependent structure in the current-enhancement factor due to the adsorbate has been interpreted in a tunneling-resonance model to yield the positions and shapes of the atomic "virtual levels." The ground-state $^1S\ 6s^2$ level of Ba is broadened to a half-width $\Gamma_S = 0.75$ eV and shifted upward by $\Delta E^S = 0.95$ eV. This causes it to overlap and mix with the first two excited states: a triplet $^3D\ 6s5d$ and a singlet $^1D\ 6s5d$. The observed ^3D and ^1D levels were not shifted and has a half-width $\Gamma_D = 0.1$ eV. Similarly, the first excited state of Ca, a triplet $^3P\ 4s4p$, was shifted by $\Delta E^{3P} \approx 0.4$ eV with a width $\Gamma_{3P} \approx 0.3$ eV ($2\Gamma =$ FWHM). The effect of the band structure of the substrate on tunneling is discussed.

11770. Powell, R. L., **Cryogenic materials needs,** (Proc. 5th Annual Natl. Conf. Industrial Research, Sept. 18-19, 1969, Chicago, Ill.), Chapter in *Applying Emerging Technologies*, pp. 102-107 (Industrial Research, Inc., Beverly Shores, Indiana, 1970).

Key words: Cryogenic fuels; food preservation; liquefied natural gas; medical technology.

Cryogenics has long been divided informally into three fields: superconductivity, liquid helium, and other. This talk is on the "other," with two special topics emphasized, cryogenic fuels and biological materials. The special fuel needs important now are hydrogen for space flight and liquefied natural gas for home use, industry, and transportation. Some applications of cryogenic techniques to medical operations and to preservation of gourmet foods are briefly described.

11771. Reed, R. P., Durcholz, R. L., **Cryostat and strain measurement for tensile tests to 1.5 K,** (Proc. 1969 Cryogenic Engineering Conf., June 16-18, 1969, Univ. of California, Los Angeles, Calif.), Chapter in *Advances in Cryogenic Engineering* **15,** Paper No. D-3, 109-116 (Plenum Press, Inc., New York, N.Y., 1970).

Key words: Capacitance extensometer; cryostat; strain measurement instruments; tensile properties.

A new tensile cryostat has been developed and tested at temperatures between 300 and 1.5 K. Better design, insulation, and vacuum-sealed environment reduces the heat leak to about 0.2 watts during continuous pumping above liquid helium. New capacitance strain-sensing equipment has been developed to provide ranges of strain sensitivities between 10^{-6} and 10^{-2} inches per inch. Details are presented of both devices.

11772. Ritter, J. J., Coyle, T. D., **Halogen exchange reactions of diboron tetrahalides,** *J. Chem. Soc.,* Sec. A, pp. 1303-1304 (1970).

Key words: Boron; boron subhalides; exchange; halides; halogen; redistribution.

Halogen exchange between BCl_3 and B_2F_4 at room temperature occurs in such a way as to concentrate chlorine on the diboron fragment and thus provides a convenient procedure for preparation of B_2Cl_4 in > 80% yield. Halogen exchange between B_2Cl_4 and Me_2BF leads, however, to formation of B_2F_4 and Me_2BCl. I.r. and n.m.r. spectra indicate the presence of hitherto undetected diboron chlorofluorides in this system and in $B_2F_4 - B_2Cl_4$ and $BF_3 - B_2Cl_4$ mixtures.

11773. Robertson, A. F., Gross, D., **Fire load, fire severity, and fire endurance,** *Am. Soc. Testing Mater. ASTM Spec. Tech. Publ.* **464,** *Fire Test Performance,* pp. 3-29 (January 1970).

Key words: Burn out; experimental fires; fire endurance; fires in buildings; fire severity; fire ventilation.

A review is presented of fire studies beginning with the work of Ingberg at the National Bureau of Standards, who attempted to relate the severity of a fire endurance test in the laboratory to the conditions existing during actual building fires. He showed the importance of weight of combustibles per unit floor area as a major factor. He recognized the importance of ventilation in controlling fire behavior but did not specify it as a separate variable. Fujita in Japan is credited with emphasing the importance of ventilation. His work has been followed and enlarged by others around the world. Ventilation parameters, compartment geometry, and fuel arrangement have been shown to exert a powerful influence. The radiance from a burning building is dependent to a large extent on the nature of the ventilating openings. Fire severity is not well defined, since it depends on the interaction of the temperature-time curve developed during a fire and the themophysical properties of the materials exposed. There is a great need for further research on the influence of fuel arrangement, building geometry, and ventilation on fires in buildings.

11774. Rockett, J. A., **Objective and pitfalls in the simulation of building fires with a computer,** *Fire Tech.* **5,** No. 4, 311-322 (November 1969).

Key words: Building; computer; fire; simulation.

The complex interactions between a building and a fire are being studied using the National Bureau of Standards computer facility. By highlighting the information needs for a successful calculation, the fire simulation study provides a guide to future research.

11775. Schneider, W. E., **A one-solar-constant irradiance standard,** *Appl. Opt.* **9,** No. 6, 1410-1418 (June 1970).

Key words: Calibration techniques; radiometric standards; solar constant; spectral irradiance; total irradiance.

A new high-intensity standard of total and spectral irradiance has been developed recently at the National Bureau of Standards. The standard consists of a 1000-W tungsten-halogen lamp mounted in a ceramic reflector, the reflecting surface of which is coated with flame-sprayed Al_2O_3. The lamp-reflector combination results in a source having a relatively small (3 cm × 5 cm) radiating area yielding a total irradiance, at a distance of 40 cm, of about 136 mW cm^{-2}. The total irradiance calibrations are based on the radiance of a 1400-K blackbody and have an estimated maximum systematic error of 0.9% and a maximum estimated standard error of 0.19%. The spectral measurements were made over the wavelength range of 0.3 μm to 2.5 μm relative to the NBS 1000-W tungsten-halogen irradiance standards. The estimated uncertainty in these measurements ranges from 4% in the visible and near ir to 8% in the uv.

11776. Sher, A. H., Coleman, J. A., **Lithium driftability in detector-grade germanium,** *IEEE Trans. Nucl. Sci.* **NS-17,** No. 3, 125-129 (June 1970).

Key words: Gamma-ray spectrometers; Ge(Li) detectors; lithium driftability; lithium mobility; semiconductor nuclear radiation detectors.

The behavior of many germanium crystals during lithium-ion drift, in terms of compensated depth W as a function of drift time t, does not follow the prediction of the equation:

$$W = (2\mu_{Li} V t)^{1/2}.$$

Modification of the lithium velocity expression to include the loss of mobile lithium ions during drift yields the expression:

$$W = \mu_{Li} V \tau (1 - e^{-2t/\tau})^{1/2}$$

which seems to describe satisfactorily the experimental results. In addition to the loss mechanism, the effect of oxygen on lithium-ion drift mobility is considered.

11777. Sher, A. H., Keery, W. J., **Variation in the effective Fano factor in a Ge(Li) detector,** *IEEE Trans. Nucl. Sci.* **NS-17,** No. 1, 39-43 (February 1970).

Key words: Charge carrier trapping; effective Fano factor; gamma-radiation; Ge(Li) detector; intrinsic Fano factor; p-i-n junction.

Variations in the value of the effective Fano factor, F′, have been observed in Ge(Li) detectors using a collimated beam of γ-rays to irradiate selected areas in the sensitive region between the n^+- and p-contacts. For regions near the n^+-contact where the trapping of electrons is minimized, F′ was found to be statistically less than 0.11.

11778. Sindt, C. F., Ludtke, P. R., **Slush hydrogen flow characteristics and solid fraction upgrading,** (Proc. 1969 Cryogenic Engineering Conf., June 16-18, 1969, Univ. of California, Los Angeles, Calif.), Chapter in *Advances in Cryogenic Engineering* **15,** Paper No. I-6, 382-390 (Plenum Press, Inc., New York, N.Y., 1970).

Key words: Flow restrictions; liquid hydrogen; liquid-solid mixtures; plug flow; slurry flow; slush hydrogen; solid hydrogen.

Flow characteristics of liquid-solid mixtures of parahydrogen (slush hydrogen) were investigated in a 16.6 mm diameter pipe, a globe valve, two orifices, and a venturi. The pressure loss as a function of slush solid fraction and volume flow rate was determined for a 14.74 m test section of the pipe. Test results are presented as pressure loss versus volume flow and as friction factor versus Reynold number. Data for triple-point liquid and slush of solid fractions up to 0.5 are presented. When Reynolds numbers in the pipe were greater than 3 × 10^5, friction losses flowing slush hydrogen at mass solid fractions of 0.2 to 0.4 were greater than friction loss flowing triple-point liquid hydrogen. At a Reynolds number of 6 × 10^4 friction losses with liquid-solid mixtures of hydrogen in the test section were always greater than losses with triple-point liquid hydrogen.

Slush of solid fractions to 0.5 flowed through the valve, orifices and a venturi with the same pressure loss as with triple-point liquid hydrogen.

Upgrading of slush hydrogen solid fraction was achieved by retaining solids with a 30 mesh screen while drawing off triple-point liquid.

11779. Snyder, N. S., **Heat transport through helium II: Kapitza conductance,** *Cryogenics* **10,** No. 2, 89-95 (April 1970).

Key words: Heat transfer; helium II; Kapitza conductance; liquid-solid interface.

A review is presented of experimental and theoretical work on the Kapitza conductance, which limits the heat that can be transferred from a solid to helium II. A short derivation of the phonon radiation limit indicates that the reason for the approximate T^3 temperature dependence of the Kapitza conductance. The small size of this upper limit makes the Kapitza conductance a critical factor in He II heat transfer applications. Considerable qualitative and quantitative correspondence of the data with this limit is found. From the limited evidence available, the role of surface conditions and bulk parameters in determining the conductance are considered empirically. An examination of the theories of Kapitza conductance which have been proposed shows that none provide adequate explanations of the data, and that the underlying physical phenomena remain obscure. Because of the scarcity of available data, and discrepancies between experiments, the prediction of Kapitza conductance for design purposes from theory or experiment is difficult.

11780. Steward, W. G., Smith, R. V., Brennan, J. A., **Cooldown transients in cryogenic transfer lines,** (Proc. 1969 Cryogenic Engineering Conf., June 16-18, 1969, Univ. of California, Los Angeles, Calif.), Chapter in *Advances in Cryogenic Engineering* **15,** Paper No. 1-2, 354-363 (Plenum Press, Inc., New York, N.Y., 1970).

Key words: Cooldown; cryogenic fluid flow; heat transfer; transfer pipelines; transients; surges.

A series of experiments in the cooldown of instrumented vacuum insulated pipelines has been performed using liquid nitrogen and liquid hydrogen. Downstream pressure surges greater than six times the inlet pressure were recorded. The observed pressure, temperature, and flow transients were reproduced within the experimental uncertainties by a digital computer program. The program can operate in one mode to obtain detailed histories of short period oscillations and in another mode to compute smoothed-out longer term transients such as wall cooldown. The program may be applied directly to pipelines fed by constant pressure sources and, with internal modification, should also be adaptable to more complex cryogenic apparatus.

11781. Stief, L. J., Payne, W. A., DeCarlo, V. J., Gorden, R., Jr., Ausloos, P., **Comment on "Xenon sensitized photolysis of carbon dioxide,"** *J. Chem. Phys.* **53,** No. 1, 475-476 (July 1, 1970).

Key words: CO_2; energy transfer; quantum yield; rare gas; sensitization; vacuum ultraviolet photolysis.

This Comment to the editor clarifies certain observations made in an earlier study of the xenon sensitized photolysis of CO_2. It is shown that contrary to earlier observations, the quantum yields of carbon monoxide in the photolysis of CO_2 - Xe (10:1) mixtures is equal to unity over the pressure range 10 to 100 torr.

11782. Straty, G. C., Prydz, R., **Melting curve and triple-point properties of fluorine,** *Physics Letters* **31A,** No. 6, 301-302 (March 23, 1970).

Key words: Density; fluorine; melting curve; β-fluorine.

The melting pressures of fluorine have been measured at 0.1 K intervals from the triple point to a maximum pressure of 13.7 MN/m^2 ($1\ MN/m^2 = 9.869\ 23$ atm). The density of solid β-F_2 at the triple point is calculated from the Clapeyron equation.

11783. Tighe, N. J., Hockey, B. J., **Ion thinning of electron microscope specimens,** (Proc. 10th Symp. Electron, Ion, and Laser Beam Tech., May 21-23, 1969, National Bureau of Standards, Gaithersburg, Md.), *Record of 10th Symposium on Electron, Ion, and Laser Beam Technology,* L. Marton, ed., pp. 375-380 (San Francisco Press Inc., San Francisco, Calif., 1970).

Key words: Al_2O_3; argon ion bombardment; ceramics; electron microscopy; hardness; ion thinning; SiO_2.

In recent years, it has been possible to prepare ceramic specimens for transmission electron microscopy using ionic bombardment for thinning bulk samples to less than ~0.5μm thickness. Chemical inertness and electrical insulating properties of many ceramic materials make chemical and electrochemical methods, such as those used for metals, difficult to apply. Even when suitable chemical polishes are found they often are useful only for certain crystallographic orientations and not at all useful for polycrystalline bodies. In this laboratory, the ion-thinning technique has been applied to polycrystalline and single-crystalline ceramics including alumina, magnesia, silica and zirconia.

Prior to ion thinning, disk specimens 2.3 or 3 mm in diameter are cut from thin slices (40 to 150μm) of the selected samples. When a specimen is particularly fragile because of large deformation, fractures, or porosity, a supporting rim is cemented to it. Specimens are thinned simultaneously from both sides and are rotated during thinning to eliminate or reduce directional grooving. They are thinned with argon ion beams using accelerating voltages of 4 to 8 kV and beam currents of 50 to 150μA. Thinning rates vary from 1/2 to 4μm/hr depending on the specimen material and on the operating conditions.

The ion-thinned specimens have electron transparent regions which usually are more extensive than those in the best chemically thinned single crystal specimens. Studies of the microstructure of hot-pressed alumina, periclase brick, quartz and magnetite rocks and a number of sintered ceramics have been undertaken. The dislocation substructure, impurity precipitates, second phase grains, and voids have been revealed by transmission electron microscopy; and, in some cases, the defects have been related to the deformation sustained by specimens during forming or during mechanical testing. Because specimens can be thinned from only one side, it has been possible to study the damage in single and polycrystalline alumina specimens which is produced by hardness indents and by mechanical polishing with diamond abrasives.

11784. Torrance, K. E., Orloff, L., Rockett, J. A., **Numerical study of natural convection in an enclosure with localized heating from below—creeping flow to the onset of laminar instability,** *J. Fluid Mech.* **36,** Part 1, 33-54 (June 1969).

Key words: Circular cylinder; enclosures; natural convection; numerical.

An analytical study was made of the natural convection induced in an enclosure by a small hot spot centrally located on the floor. The enclosure was a circular cylinder, vertically oriented, with height equal to radius. A Prandtl number of 0.7 (air) was assumed; the Grashof number *(Gr)* was based on cylinder height and hot spot temperature. The equations of fluid flow in axisymmetric cylindrical co-ordinates were simplified with the Boussinesq approximation. The equations were solved numerically with a computationally stable, explicit method. The computation, starting from quiescent conditions, proceeded through the intial transient to the fully developed flow. Solutions were obtained for Gr from 4×10^4 to 4×10^{10}. The theoretical flows are in excellent agreement with experimentally observed laminar flows ($Gr \lesssim 1.2 \times 10^9$) which are discussed in a companion paper, Torrance, Orloff & Rockett (1969). Turbulence was observed experimentally for $Gr \gtrsim 1.2 \times 10^9$. When the theoretical calculations were extended to $Gr = 4 \times 10^{10}$, a periodic vortex shedding developed, suggestive of the onset of laminar instability. The theoretical results reveal a$\sqrt{Gr}$ scaling for the initial flow transients and, at large Gr, the velocities and heat transfer rates.

11785. Torrance, K. E., Orloff, L., Rockett, J. A., **Experiments on natural convection in enclosures with localized heating from below,** *J. Fluid Mech.* **36,** Part I, 21-31 (1969).

Key words: Enclosures; flow visualization; modeling; natural convection.

An experimental study was made of the steady-state natural convection induced in enclosures by a small hot spot centrally located on the floor. Enclosures of rectangular and circular floor plan were employed, with height equal to one-half the major dimension of the floor plan. The movement of air within the chambers was made visible by adding metaldehyde dust particles and illuminating them with an intense light beam. The Grashof number *(Gr)* based on hot-spot temperature and enclosure height ranged from 8×10^5 to 1×10^{10}. Laminar flows were observed for $Gr \leq 1.2 \times 10^9$. The experimental flows in the circular chamber are compared in a companion paper with theoretically calculated flows (Torrance & Rockett 1969). In the region of laminar flows the agreement was excellent. The present paper notes certain similarities in the flows in rectangular and circular geometries. The disturbing effect of a slight heating of one wall of the rectangular enclosure was also investigated. Measurements were made of heat transfer from the hot spot to the air in the chamber.

11786. Verdier, P. H., **Relaxation behavior of the freely jointed chain,** *J. Chem. Phys.* **52,** No. 11, 5512-5517 (June 1, 1970).

Key words: Chain dynamics; polymers; random walk; relaxation; stochastic process.

A method is presented for treating the relaxation behavior of the freely jointed chain model of a random coil polymer. Exact results are exhibited for the relaxation of quantities linear in chain coordinates. For the treatment of quantities quadratic in chain coordinates, a numerical approach is employed and exemplified by obtaining the autocorrelation in the square of end-to-end length for chains of up to 16 beads. In both cases, the rapid approach of the behavior of the freely jointed chain of N beads to that of the Rouse model of N statistical segments is demonstrated.

11787. Weber, L. A., **The P-V-T surface of oxygen in the critical region; densities of saturated liquid and vapor,** (Proc. 1969 Cryogenic Engineering Conf., June 16-18, 1969, Univ. of California, Los Angeles, Calif.), Chapter in *Advances in Cryogenic Engineering* **15,** Paper No. B-4, 50-57 (Plenum Press, Inc., New York, N.Y., 1970).

Key words: Critical density; critical point; critical temperature; oxygen; properties of fluids; P-V-T; saturation densities.

A description is given of an apparatus used to determine the detailed nature of the *P-V-T* surface of fluids in the critical region by means of dielectric measurements. Preliminary data are presented for the saturation densities of oxygen within one degree of the critical temperature. Analysis of the data yields the following values of the critical parameters: $T_c = 154.575 \pm .010$ K, $\rho_c = 0.4361 \pm .0005$ gm/cm^3.

11788. Weiss, A. W., Krauss, M., **Bound-state calculation of scattering resonance energies,** *J. Chem. Phys.* **52,** No. 9, 4363-4368 (May 1, 1970).

Key words: Ar; correlation energy; Feshbach resonance state; Hartree-Fock; He Ne; HF H_2O; N_2, resonance energy; Rydberg; valence.

Resonance energies in electron scattering are estimated by calculating bound trial functions which represent electron attachment to the lowest Rydberg state. The trial functions are kept orthonormal to a single-configuration description of the target state and so represent an approximation to the Feshbach procedure. Correlated trial functions are used for He$^-$(^2S), Ne$^-$(^2P), and Ar$^-$(^2P). The resonant-energy predictions are in good agreement with observation. In addition, the correlation energy for the ns^2 pairs range from 0.55 to 0.75 eV. These correlation energies are used to correct Hartree-Fock estimates of resonance energies computed for the HF, H_2O, and N_2 molecules. Energy curves obtained for HF$^-$($^2\Pi$) indicate a dissociative attachment process is possible that leads to production of the H$^-$ ion. Only single points are calculated for H_2O but the $^2B_1$ resonance state is assigned to a dissociative attachment at 6.5-eV incident electron energy that yields the H$^-$ ion. In addition to the attachment to Rydberg excited states, two N_2 valence-type Feshbach states are calculated. The results for $\sigma_g\pi_g^2$, $^4\Sigma_g^-$, and $^2\Delta_g$, when used with correlation energy estimates lead to the conclusion that valence-type Feshbach states are not bound relative to their concomitant neutral excited valence state. Sharp resonances would not then be expected below such neutral states.

11789. Wilson, W. K., **Development of specifications for archival record materials,** *Am. Archivist* **33,** No. 2, 219-223 (April 1970).

Key words: Acidity; aging; alum sorption; laboratory aging; manifold; paper; records; stability; stability of cellulose; stability of paper; thermal analysis.

Work in progress on the development of information on the stability of paper and modified cellulose is described in relation to the objectives of the program. Plans for calendar year 1970 are outlined.

11790. Winogradoff, N. N., Neill, A. H., Jr., **Temperature dependence of the power output of the spontaneous emission from GaAs laser diodes,** *Intern. J. Electron.* **28,** No. 5, 401-406 (1970).

Key words: Band filling; band tailing; GaAs; gallium arsenide; internal quantum efficiency; lasers; radiative recombination; temperature dependence; valence band.

Modulation of photoluminescence in *p*-type GaAs by a field effect indicated that the radiative recombination occurred through recombination centers. This suggested that the recombination rate in the depletion region of a luminescent *p-n* junction would be governed by Shockley-Read statistics. The resulting model showed that, with suitable diode parameters, an *increase* in temperature would produce an *increase* in the radiative efficiency of the diode. Such an effect was observed experimentally with vapor-grown GaAs *p-n* junctions, the *p*-type sides of which were heavily compensated.

11791. Winogradoff, N. N., Neill, A. H., Jr., Petrescu-Prahova, J. B., **Band tailing and the spontaneous spectra of compensated epitaxial GaAs laser junctions,** *IEEE J. Quantum Electron.* **Q.E. 6,** No. 6, 305-310 (June 1970).

Key words: Band tailing; GaAs lasers; non-radiative recombination centers; radiative recombination; temperature dependence; valence band.

The spectra of the spontaneous emission from GaAs laser diodes fabricated by vapor-phase epitaxy and containing a high degree of compensation in the *p*-type side of the junction are, in many respects, similar to those previously reported for the cathodoluminescence of homogeneous *p*-type material. The temperature dependence of the spectra of these diodes supports a model where the emission is attributed to radiative transitions between a narrow band of states near the conduction-band edge and an exponential distribution of states extending the valence band into the forbidden gap.

An increase in temperature then results in an *increase* or a decrease in the radiative power output depending on the position of the quasi-Fermi level for electrons relative to the above narrow band of states and a distribution of nonradiative levels below it.

11792. Wolfe, W. C., **Performance tests for floor coverings,** *Mater. Res. Stand.* **10,** No. 7, 15-18 (July 1970).

> Key words: Carpet; floor coverings; foot comfort; performance requirements; resilient types; test methods; textile types; vehicle movement.

Well defined performance tests are an essential element of performance specifications, standards, and codes. The particular needs of the floor covering industry for such tests are pointed up by a discussion of the performance concept in terms of this industry. Performance requirements are listed by categories, to assist in identifying those requirements most important for inclusion in future performance specifications, and to provide guidance for research towards test methods of maximum possible usefulness and significance.

The National Bureau of Standards has recently developed two types of performance tests for floor coverings, considered from the standpoint of comfort, convenience, and efficiency. They are concerned with resistance to movement of wheeled vehicles and with resilience as related to foot comfort in hospitals. These are important factors to consider in deciding whether or not to use carpet.

Other performance requirements under study relate to health and safety, especially fire safety, and to economic criteria such as wear or durability.

Future work on performance tests needs extensive government-industry cooperation, encompassing interlaboratory comparisons and field-laboratory correlations.

11793. Wood, L. A., **Creep of "pure-gum" vulcanizates of natural rubber,** (Proc. Intern. Natural Rubber Conf., Kuala Lumpur, Malaya, Sept. 1968), *J. Rubber Res. Inst. Malaya* **22,** No. 3, 309-316 (1969).

> Key words: Compliance; creep; dicumyl peroxide vulcanizates; indentation of rubber; modulus; natural; natural rubber; rubber; strain-time relations; vulcanizates.

The creep of vulcanizates of natural rubber cured with varying amounts of dicumyl peroxide was compared with that of vulcanizates cured by typical conventional sulphur-accelerator systems. The measurements involved indentation of a flat rubber disc as a function of time t and temperature T. The product of shear compliance J and T as a function of log t was represented by a family of curves with T as the parameter. For the vulcanizates curved with the sulphur-accelerator system, previous work has shown that the individual curves could be shifted along the abscissa to yield a single continuous curve with a slope which increased from a negligible value to a maximum and then decreased, continuing through a region of minimum slope which extended over about 7 decades of time before ending in a region of increasing slope. The value of the creep was 1.5-2.0% per decade in the region of minimum slope.

When the same procedures were applied to the vulcanizates cured with dicumyl peroxide, the individual curves of JT against log t at each temperature did not yield a single continuous curve when shifted. In a limited region just above the glass transition temperature, the creep was appreciable, but neither a constant-activation-energy shift nor a Williams-Landle-Ferry shift was satisfactory. Above this region it was clearly impossible to obtain a single curve, since the compliance-temperature product at a given time increased with increasing temperature while the corresponding creep of the dicumyl peroxide vulcanizates was generally too small (<0.5% per decade) to be measured between 5 and 600 seconds, except when the compound contained less than 2.5 parts of effective dicumyl peroxide. Outside of these regions the shear modulus was found to increase linearly with temperature. The investigation included temperatures as high as 100 °C and effective dicumyl peroxide concentrations as high as 25 parts per hundred of rubber. The present results for the modulus and creep of dicumyl peroxide systems show good agreement with the published data of Chasset and Thirion (obtained by stress relaxation at 30 °C) and of Plazek (obtained by a torsion pendulum) over the ranges they investigated.

11794. Wood, L. A., Shouse, P. J., Passaglia, E., **How just appreciable fading of AATCC L-4 wool standard is related to exposure time,** *Textile Chem. Colorist* **2,** No. 11, 182-190 (June 3, 1970).

> Key words: Appreciable fading; fading; light-sensitive paper; paper, light-sensitive; Standard Fading Hour; wool standards.

The color difference resulting from "just appreciable fading" of AATCC's L-4 Wool Standard, as judged by a panel of experts, is found to be about 1.5 units, as calculated by inserting the results of spectrophotometric measurements in the Adams chromatic-value relation, the Scofield-Hunter relation or the cube-root relation of Glasser, et al.

This value corresponds to about 3.0 NBS units of color difference. The change is equivalent to Step 4 of the International Geometric Gray Scale, which is defined by the Adams chromatic value relation. Fading of the wool standard to this extent was produced in slightly less than 14 hours in the NBS Master Carbon-Arc Lamp—an exposure equivalent to about 11 NBS Standard Fading Hours (SFH).

11795. Moore-Sitterly, C. E., **Rare-earth spectra—the 1966 picture,** *Proc. First International Conf. Spectroscopy, Bombay, India, January 9-18, 1967,* **1,** 1-13 (1967).

> Key words: Astrophysical data on rare earths; atomic spectra; configurations; ground states; rare earth spectra.

The large and familiar program on the compilation of "Atomic Energy Levels" as derived from the analyses of optical spectra, continues. The last and fourth volume of the series will contain similar data on the atomic spectra of the two groups of rare earth elements: The lanthanon group, Ce thru Lu ($Z=58$ thru 71) and the action group, Th thru Lw ($Z=90$ thru 103).

The first spectra have low ionization potentials. Most of the earlier line lists do not separate the first and second spectra, and are wholly inadequate for analysis work. Suitable sources for separating spectra of different degrees of ionization have been developed, and the individual spectra are now being observed over a long spectral range. A number of homogeneous line lists exist, some of which contain more than 15,000 lines for a given spectrum.

Rare earth spectra are characterized by configurations involving f-electrons, and a number have overlapping configurations which explains the complexity of the spectra. So far, little is known beyond fourth spectra. The progress in this relatively new field of research is reported in some detail, along with brief mention of the present astrophysical needs for data on atomic spectra of the rare earths.

11796. Moore-Sitterly, C. E., **Fundamental spectroscopic data, IAU Commission 14, August 1967 Meeting,** *Trans. Intern. Astron. Union* **13A,** 229-266 (1967).

> Key words: Cross sections; Draft Report IAU Commission 14; International Astronomical Union; spectroscopic data; transition probabilities; wavelength standards.

The present report summarizes important activities in the field since the Twelfth General Assembly of the Union held in Hamburg in 1964. The main topics deal with standards of wavelength, transition probabilities, line broadening, atomic collision cross sections, molecular spectra of astrophysical interest, general progress in studies of laboratory spectra and current work on the solar spectrum.

11797. Ku, H. H., **Statistical concepts in metrology,** Chapter 2 in *Handbook of Industrial Metrology,* pp. 20-54 (Prentice-Hall, Inc., Englewood Cliffs, N.J., 1967).

Key words: Control chart; data analysis; measurement process; metrology; precision; propagation of error; standard deviation; statistical concepts.

This chapter deals with statistical concepts of a measurement process and statistical analysis of measurement data, and is part of the text book *Industrial Metrology* sponsored by the American Society of Tool and Manufacturing Engineers.

Beginning with the differentiation between arithmetic and measurement numbers, the properties of the latter are developed and described, leading to a discussion of precision and accuracy.

A basic kit of tools for the comparison and manipulation of means and variances are given, including a collection of propagation of error formulas. The use of control chart techniques for monitoring stability is emphasized. Examples are given using actual calibration data of NBS.

Selected references are given for topics introduced but not treated in detail.

5. INDEXES

5.1. 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 Periodicals

NBS Journal of Research	Index Symbol			Issue Date	Page Number
	Vol.	Sec.	No.		
Section A	J74	A	1	January–February 1970	21
	J74	A	2	March–April 1970	22
	J74	A	3	May–June 1970	24
	J74	A	4	July–August 1970	26
	J74	A	5	September–October 1970	28
	J74	A	6	November–December 1970	30
Section B	J74	B	1	January–March 1970	32
	J74	B	2	April–June 1970	32
	J74	B	3	July–September 1970	33
	J74	B	4	October–December 1970	34
Section C	J74	C	1	January–June 1970	35
	J74	C	3	July–December 1970	36

Table B. Symbols for the Nonperiodicals

NBS Nonperiodical Series	Index Symbol	Page Number
Monographs	Monogr.	38
Handbooks	H	40
Special Publications	SP	41
Applied Mathematics Series	AMS	48
National Standard Reference Data Series	NSRDS	49
Building Science Series	BSS	50
Federal Information Processing Standards	FIPS PUBS	53
Product Standards	PS	54
Technical Notes	TN	56
Consumer Information Series	CIS	67

Table C. Symbols for the Papers Published By Others (1970)

NBS Papers Published by Others (1970)	Index Symbol	Page Number
Professional Journals, Book, Book Chapters, Proceedings, etc.	Four-Digit numbers, 10863 through 11797	68

5.2. AUTHOR INDEX

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Temperature changes in tensile specimens; 4340 steel; Capacitance gages; Invar; Loading rate; Microplasticity; Strain measurement; *11738.*

Temperature classification, Dy I and Dy II; Spectra, Dy I and Dy II; Intensity estimates, Dy spectra; Dysprosium spectra, temperature classification; J.74A *No. 3, 355-394 (1970).*

Temperature coefficient; Bismuth transition; Calibration point; High pressure; Pressure measurement; J.74A *No. 1, 51-63 (1970).*

Temperature coefficients of e.m.f.; Silver-silver chloride electrode; Glass electrode; Inner solutions; PH measurement calomel electrode; Reference electrodes; *11247.*

Temperature compensation; Thermoelement; Transfer voltmeter; Voltage converter; Emf comparator; Frequency compensation; *11200.*

Temperature dependence; Cadmium fluoride; Dielectric constant; Pressure dependence; *11608.*

Temperature dependence; Valence band; Band filling; Band tailing; GaAs; Gallium arsenide; Internal quantum efficiency; Lasers; Radiative recombination; *11790.*

Temperature dependence; Valence band; Band tailing; GaAs lasers; Non-radiative recombination centers; Radiative recombination; *11791.*

Temperature dependence; X-ray diffraction; Defects; *n*-paraffins; Phase transition; J.74A *No. 2, 203-214 (1970).*

Temperature gradients in calorimeters; Tempering of leads; Design principles; Heat leak errors; Heat transfer; *10961.*

Temperature measurement; Automatic phase balance; Bridge; Multistage transformers; Operational amplifiers; Resistance bridge; Resistance thermometry; J.74C *Nos. 1 and 2, 14-17 (1970).*

Temperature measurement; H_β profiles; Plasma arcs; Stark broadening; *11126.*

Temperature measurement; Thermistor; Thermocouple; Conduction error; Radiation error; Resistance thermometer; *BSS26.*

Temperature measurement; Thermometry; Temperature; *10885.*

Temperature scale; Cerous magnesium nitrate; Low temperatures; Magnetic cooling; Magnetic thermometer; Paramagnetic salt; *10991.*

Temperature scale region of 40 to 900 °C; Temperature scale standards; ASTM Committee; Differential thermal analysis; International Committee on Thermal Analysis; *SP338,* pp. 61-86.

Temperature scale standards; ASTM Committee; Differential thermal analysis; International Committee on Thermal Analysis; Temperature scale region of 40 to 900 °C; *SP338,* pp. 61-86.

Temperature scales; Thermometry; Temperature; *11503.*

Temperature standards; TGA; Theory of isoperibol and adiabatic shield calorimeters; Atherosclerotic plaque; DSC; Elastomers and vulcanizates; Explosives; High temperature DTA; Kinetics by TGA; Selection of DTA parameters; *SP338.*

Tempering; Through hardening steel; Ceramic; Cermets; Dimensional stability; Gage blocks; Length standards; Precipitation hardening steel; Secondary hardening steel; *11223.*

Tempering of leads; Design principles; Heat leak errors; Heat transfer; Temperature gradients in calorimeters; *10961.*

Tempering temperature; Tensile strength; Yield strength; AISI 5140 steel; Hardness; Heat treatment; Reduction of area; Slack-quenched structures; *10984.*

Temporal dimensional stability; Ultrastability; Gage blocks; Maraging steel; Nitriding; Precision equipment; Surface hardened; *11596.*

Tensile; Welded; Brazed; Copper; Low temperature; Notch-tensile; *11432.*

Tensile properties; Capacitance extensometer; Cryostat; Strain measurement instruments; *11771.*

Tensile properties; Tungsten; Vapor-deposition; Wires; Composites; Copper; Electrical conductivity; Fracture; Law of mixtures; Metallic bonding; J.74C *Nos. 3 and 4, 97-110 (1970).*

Tensile strength; Time of setting; Vicat; Autoclave soundness; Hydraulic cement; Normal consistency; *10907.*

Tensile strength; Yield strength; AISI 5140 steel; Hardness; Heat treatment; Reduction of area; Slack-quenched struc-

Theory; Wave field; Wave packet; X-ray diffraction; Atom; Displacement; Distorted crystal; Energy flow; Finite beam; *11031.*

Theory; Xenon; Absolute; Cross section; Electron; Generalized oscillator strengths; *11017.*

Theory; Zeeman effect; Chromium; Configurations in Cr I; Configurations $(3d+4s)^5 4p$ in Cr I; Configuration interaction; Cr I; **J.74A** *No. 2, 157-179 (1970).*

Theory of cement hardening; Time of set; Vane-shear apparatus; Cement; Cement mortar; Cement paste; Early strength; False set; Hardening of cement; Hydration; Shear resistance; *BSS28.*

Theory of computation; Combinatorics; Dynamic programming; Optimization; Systems of distinct representatives; **J.74B** *No. 4, 243-247 (1970).*

Theory of isoperibol and adiabatic shield calorimeters; Atherosclerotic plaque; DSC; Elastomers and vulcanizates; Explosives; High temperature DTA; Kinetics by TGA; Selection of DTA parameters; Temperature standards; TGA; *SP338.*

Thermal; Transient; Absorption; Acoustic; Adiabatic; Fluid; Heat-conducting; Inviscid; Isothermal; Kirchoff-Langevin equation; Stability; Steady-state; **J.74B** *No. 2, 67-84 (1970).*

Thermal; 8-hydroxyquinoline; Bis(8-hydroxy-5-quinolyl)methane; Coordination; Copper; Decomposition; Infrared spectrophotometry; Ligand; Mass spectrometry; Polymer; *11261.*

Thermal analyses; Analyses of thermal apparatus; Differential scanning calorimetry; Evaluation of heats and temperatures of transition; Instrumental time constants; Interfacial thermal conductivity; *SP338,* pp. 119-136.

Thermal analyses; Thermodynamic laws; Equilibria; Freezing point equation; Ideal solution laws; *11471.*

Thermal analysis; Acidity; Aging; Alum sorption; Laboratory aging; Manifold; Paper records; Stability; Stability of cellulose; Stability of paper; *11789.*

Thermal analysis DTA standards; Trace elements-glass standards; Bilirubin solvent extraction with β-isopropyltropolone; Clinical; Filter; Fluorimetric standards; Inert gas fusion; Lead-base alloys; Multi-element flame spectrometer; Spectrophotometric standards; Steels and metallo-organics; *TN544.*

Thermal analysis; Thermal degradation; Thermogravimetric analysis; Differential thermal analysis; DTA; Kinetics; Pyrolysis; TGA; *SP338,* pp. 137-150.

Thermal conductance; Thermal conductivity; Conductance; Conductivity; Heat transfer; Nuclear safety; Soils; Temperature; *10944.*

Thermal conductance; Thermal conductivity; Conductance; Conductivity; Heat transfer; Nuclear safety; Soils; Temperature; *11305.*

Thermal conductance of contacts; ^{3}He cryostat; Low temperature; Low temperature calorimetry; Mechanical heat switch; Pressed contacts; *11270.*

Thermal conductivity; Conductance; Conductivity; Heat transfer; Nuclear safety; Soils; Temperature; Thermal conductance; *10944.*

Thermal conductivity; Conductance; Conductivity; Heat transfer; Nuclear safety; Soils; Temperature; Thermal conductance; *11305.*

Thermal conductivity; Conductivity; Electrical conductivity; Electrical resistivity; Heat conductivity; Lorenz function; Platinum; Reference material; Resistivity; Standard; *11304.*

Thermal conductivity; Critical region; Parahydrogen; *11734.*

Thermal conductivity; Thermal gradient; Thermal flux; Turbulence; Two-fluid hydrodynamics; Vorticity; Helium II, superfluid; *11718.*

Thermal conductivity; Thermopower; Titanium alloy; Aluminum alloy; Electrical resistivity; Lorenz ratio; Nickel alloy; *11336.*

Thermal conductivity; Transport properties; Cryogenics; Electrical resistivity; Equipment; Error analysis; Iron; Lorenz ratio; Seebeck effect; **J.74A** *No. 5, 673-690 (1970).*

Thermal conductivity; Transport properties; Viscosity; Compressed gases; *11119.*

Thermal conductivity; Viscosity; Absorption; Acoustic propagation; Fluids; Kirchhoff-Langevin; Navier-Stokes; Stability; *11694.*

Thermal conductivity; Viscosity; Corresponding states; Enskog theory; Helium-four; Kinetic theory; Quantum fluid; *10971.*

Thermal conductivity; Viscosity; Correlation; Density dependence; Kinetic theory; Least squares analysis; Logarithmic expansion; *10972.*

Thermal conductivity; Viscosity; Dissociation; Hydrogen; Intermolecular potential functions; Kinetic theory; Quantum gas; **J.74A** *No. 3, 331-353 (1970).*

Thermal degradation; Thermogravimetric analysis; Differential thermal analysis; DTA; Kinetics; Pyrolysis; TGA; Thermal analysis; *SP338,* pp. 137-150.

Thermal emf; Transition metal oxides; Conductivity; Ferrites; Hall mobility; *11342.*

Thermal emf; W-3% Re and W-25% Re thermoelements; Argon; Evaporation; Exposure; Hydrogen and high vacuum environments; Metallographic examination; Stability; *11683.*

Thermal expansion; Alloys; Aluminum; Copper; Expansivity; Iron; Metals; Nickel; *10876.*

Thermal expansion $AgNO_3$; Unit cell dimensions $AgNO_3$; $AgNO_3$; Density $AgNO_3$; Polymorphism $AgNO_3$; *11044.*

Thermal expansion $AgNO_3$; Unit cell dimensions $AgNO_3$; $AgNO_3$; Density $AgNo_3$; Polymorphism $AgNO_3$; *11750.*

Thermal flux; Turbulence; Two-fluid hydrodynamics; Vorticity; Helium II, superfluid; Thermal conductivity; Thermal gradient; *11718.*

Thermal gradient; Thermal flux; Turbulence; Two-fluid hydrodynamics; Vorticity; Helium II, superfluid; Thermal conductivity; *11718.*

Thermal insulation; Cryogenics; Conductivity; Diffusivity; Powders; *11358.*

Thermal neutron detection; Acoustic cavitation; Boron (n,α) lithium reaction; Cavitation; Neutron detection; Radiation-induced cavitation; *11741.*

Thermal neutrons; X rays; Calibration; Data processing; Evaluation; Gamma rays; Intercomparison; Performance; Personnel dosimetry; Phosphate glass; Photographic film; Radioactive sources; *10920.*

Thermal noise; Available power ratio; Microwave multiport; Nonreciprocal multiports; *11176.*

Thermal noise; Low-frequency detector; Noise power; Noise temperature; Operational amplifiers; *11216.*

Thermal oscillations; Two-dimensional lattice dynamics; Energy calculations; Grüneisen parameter; Lattice stability; Shock wave propagation; *11165.*

Thermal properties; Adhesive; Low temperature; Mechanical properties; Polymer; Polyurethane; Resilience; *11515.*

Thermal properties; Combustion; Conduction; Diffusion flames; Flame spread; Heat transfer; Integral equations; Mass transfer; Radiation; Reaction kinetics; *11285.*

Thermal radiation properties; Thermodynamics; Electrical resistivity; Emittance; Heat capacity; High-speed measurements; High temperature; Molybdenum; **J.74A** *No. 1, 65-92 (1970).*

Thermal relaxation; Volume viscosity; Activity coefficients; Binary mixture; Brillouin scattering; Fluctuations; Light scattering from solutions; Rayleigh scattering; *11686.*

Thermal resistance; Thermographic measurements; Ultrasonic microphone; Wire bonds. ; Alpha detectors; Aluminum wire;

Carrier lifetime; Die attachment; Electrical properties; Epitaxial silicon; Gamma detectors; Germanium; Gold-doped silicon; *TN520.*

Thermal resistance; Thermographic measurements; Ultrasonic bonder; Wire bonds; Alpha-particle detectors; Aluminum wire; Carrier lifetime; Die attachment; Electrical properties; Epitaxial silicon; Gamma-ray detectors; Germanium; Gold-doped silicon; *TN555.*

Thermal shock; Ceramics; Fracture; Fracture surface energy; Strength; *11524.*

Thermal studies; Atherosclerosis; Cholesterol and its fatty acid esters; Differential scanning calorimetry; Lecithin; Lipid-water systems; Phospholipids; Sphingomyelin; *SP338,* pp. 99-117.

Thermalization length; Noncoherent scattering; Radiative transfer; Spectral line; *11444.*

Thermistor; Thermocouple; Conduction error; Radiation error; Resistance thermometer; Temperature measurement; *BSS26.*

Thermocouple; Conduction error; Radiation error; Resistance thermometer; Temperature measurement; Thermistor; *BSS26.*

Thermocouples; Cryogenics; Gold alloy; *11454.*

Thermodynamic and transport properties; Accession list; Atomic and molecular properties; Chemical kinetics; Colloid and surface properties; Fundamental particles properties; General collections; Mechanical properties; Nuclear properties; Solid state properties; *TN554.*

Thermodynamic and transport properties; Atomic and molecular data; Chemical kinetics; Colloid and surface properties; Data systems design; Information services; Mechanical properties; Nuclear data; Solid state data; Standard reference data; *TN553.*

Thermodynamic cavitation; Cavitation; Cavitation inception; Cryogenic cavitation; Developed cavitation; *11298.*

Thermodynamic constants for HCl transfer; Activity coefficients; Non-aqueous emf; Standard emf; **J.74A** *No. 5, 641-645 (1970).*

Thermodynamic cycles; Applications; Cryogenic; Refrigeration; *11520.*

Thermodynamic equations; Alloys; Cross terms; Diffusion, Multicomponent alloys; Random alloys; *11595.*

Thermodynamic equilibrium; Collisional processes; LTE; Radiation field; State parameters; Stellar atmosphere; *10957.*

Thermodynamic equilibrium; Collisional processes; LTE; Radiation field; State parameters; Stellar atmosphere; *10958.*

Thermodynamic laws; Equilibria; Freezing point equation; Ideal solution laws; Thermal analyses; *11471.*

Thermodynamic properties; α-beryllium nitride; Calorimeter; Entropy; Heat capacity; Specific heat; **J.74A** *No. 5, 617-629 (1970).*

Thermodynamic properties; β-lithium hexafluoroaluminate; Calorimetry; Entropy; Heat capacity; **J.74A** *No. 5, 631-639 (1970).*

Thermodynamic properties; Calorimetric methods; Calorimetry; Drop calorimetry; *10908.*

Thermodynamic properties; Computer algorithm; Psychrometrics; Saturated and unsaturated moist air; *BSS21.*

Thermodynamic properties; Thermodynamics; Thermometry; Time; Vaporization correction; Adiabatic calorimetry; Calorimeters; Calorimetry; Cryoscopy; Cryostats; Curvature correction; Heat-leak correction; Low temperature calorimetry; Phase studies; *11189.*

Thermodynamic properties; Three-phase loci; Apparatus; Argon-methane data; Liquid-vapor; Low temperature; Phase equilibrium; Solid-vapor; *11735.*

Thermodynamic properties; Transport properties; Air; Bibliography; Equation of state; Low temperature; Mechanical properties; *TN383.*

Thermodynamic properties; Trifluorosilane; Ultraviolet spectrum; Vacuum-ultraviolet photolysis; Force constants; Infrared spectrum; Matrix isolation; SiF_3 free radical; *11234.*

Thermodynamic properties; Two-phase; Fluorine; Liquid-vapor coexistence; Saturated liquid; Saturation; Specific heats; **J.74A** *No. 4, 499-505 (1970).*

Thermodynamic properties; Ultraviolet spectrum; Vacuum-ultraviolet photolysis; Carbon atom reaction; CF; Force constants; HCF; H_2CF; HF reaction; Infrared spectrum; Isotopic substitution; Matrix isolation; Methyl fluoride; *11341.*

Thermodynamic properties; Vacuum; Vacuum measurement; Barium nitride; Dissociation equilibria; Nitrides; Nitrogen; **J.74A** *No. 1, 45-49 (1970).*

Thermodynamics; Acidity; Bis-tris; 2,2-bis(hydroxymethyl)-2,2′2″-nitrilotriethanol; Buffer solutions; Dissociation constant; Ionization constant; PH; PK; *11602.*

Thermodynamics; Acidity; Deuteriophosphoric acid; Deuterium oxide; Dissociation constant; Emf measurements; Isotope effects; Phosphoric acid; PK; *11601.*

Thermodynamics; Acidity; Ion activity; Medium effect; Nonaqueous solvents; PH; *11249.*

Thermodynamics; Activity coefficients; Emf measurements; Enthalpy; Entropy; Ethanol-water solvents; Hydrochloric acid; *11086.*

Thermodynamics; Adiabatic calorimetry; Calorimeter; Calorimetry; Cryoscopy; Melting; Phase transition; Purity; *11188.*

Thermodynamics; Binary liquid mixtures; Critical opalescence; Critical phenomena; Critical point; Critical region; Equilibrium critical phenomena; Gases; Liquids; Liquid-vapor systems; Phase transitions; Ternary liquid mixtures; *SP327.*

Thermodynamics; Bulk; Chain fold; Crystallization; Fluctuation; Growth; Heat of melting; Homogeneous nucleation; Kinetics; Lamella thickness; Melt; Melting point; Nucleation; Polymer; Solution; Surface free energy; Theory; *11329.*

Thermodynamics; Cells; Emfs; Free energies of formation; Fused salts; Halides; *11526.*

Thermodynamics; Dissociation constant; Ionization constant; Methanol; Mixed solvents; Piperazine; PK; **J.74A** *No. 5, 667-671 (1970).*

Thermodynamics; Electrical resistivity; Emittance; Heat capacity; High-speed measurements; High temperature; Molybdenum; Thermal radiation properties; **J.74A** *No. 1, 65-92 (1970).*

Thermodynamics; Evaluated data; Liquid-vapor equilibria; Methane-*n*-pentane system; *n*-pentane; *NSRDS-NBS32.*

Thermodynamics; Excluded volume; Lattice; Monte Carlo; Polymers; Random walks; *11218.*

Thermodynamics; Thermometry; Time; Vaporization correction; Adiabatic calorimetry; Calorimeters; Calorimetry; Cryoscopy; Cryostats; Curvature correction; Heat-leak correction; Low temperature calorimetry; Phase studies; Phase transitions; Power; *11189.*

Thermodynamics; Thermophysical properties; High-speed measurements; High temperature; Specific heat; *11727.*

Thermodynamics of dissociation; Acidic dissociation; Bicarbonate ion; Carbonic acid; Deuteriocarbonate ion; Deuterium oxide; Dissociation of acids; Emf measurements; Heavy water; Isotope effects; *11418.*

Thermoelement; Transfer standard; Ac; Calibration; Dc; Intercomparison; *11170.*

Thermoelement; Transfer voltmeter; Voltage converter; Emf comparator; Frequency compensation; Temperature compensation; *11200.*

Thermographic measurements; Ultrasonic microphone; Wire bonds. ; Alpha detectors; Aluminum wire; Carrier lifetime; Die attachment; Electrical properties; Epitaxial silicon; Gamma detectors; Germanium; Gold-doped silicon; Indium antimonide; *TN520.*

reference material; Viscosity; *SP260-23.*

Visible; Complex dielectric constant; Electron-energy-loss; Electronic band structure; Infrared; Least-squares fit to optical data; Optical constants; Reflectance; Ultraviolet; *11555.*

Visible emission; Energy transfer; Infrared emission; Lattice phonons; Photoluminescence; Strontium titanate; *10965.*

Vision; Adaptation; Color; Hue; *11529.*

Vision; Chromaticity; Color; Perception; Protanopia; Tritanopia; **J.74A** *No. 1, 23-30 (1970).*

Vision; Color discrimination; Signal lights; *11208.*

Visual responses; Environmental design; Human factors; Interdisciplinary study; Relative motion; Transportation; Urban design; *11318.*

Vitreous-selenium; Grüneisen's parameter; Linear thermal expansion; *11019.*

VLF propagation; WWVL; Effect of mass on frequency; Flicker noise; NBS; Noise correlation; NSS; Optimum filter; Phase noise; Radio propagation; Time comparison; USNO; *11241.*

VMA; β-NAD; β-NADH; "Azobilirubin"; Bilirubin; Cholesterol; Cortisol; D-mannitol; Electron spin resonance; Proton magnetic resonance; Skew conformations; Standard reference materials; Uric acid; *TN547.*

Vocabulary; Computers; Data processing; Definitions, Federal Information Processing Standards Publication; Information processing; Terms; *FIPS PUB. 11.*

Voltage; Waveform; Waveguide junction; Admittance; Antenna; Attenuator; Bolometer; Calorimetry; Horn; Impedance; Interferometry; Measuring system; Phase; Power; Radiometry; Resonant cavity; *SP300. Volume 4.*

Voltage comparator; Voltage divider; Attenuator; Binary divider; Inductive voltage divider; Ratio transformer; *11328.*

Voltage comparator; Voltage monitor; Voltmeter; Detector networks; Differential voltmeter; *10912.*

Voltage converter; Emf comparator; Frequency compensation; Temperature compensation; Thermoelement; Transfer voltmeter; *11200.*

Voltage divider; Attenuator; Binary divider; Inductive voltage divider; Ratio transformer; Voltage comparator; *11328.*

Voltage monitor; Voltmeter; Detector networks; Differential voltmeter; Voltage comparator; *10912.*

Voltage standard; Dipole moment; HCN resonance spectrum; Maser spectrometer; Stark effect; **J.74A** *No. 6, 791-799 (1970).*

Voltage standard; Zener diode; Electrical measurements; Instrumentation; Standard cell; *10925.*

Voltmeter; Detector networks; Differential voltmeter; Voltage comparator; Voltage monitor; *10912.*

Volume; Anderson-Grüneisen parameter; Bulk modulus; Compressibility; Grüneisen constant; Pair potential; Paraffins; Polyethylene; Polymers; Pressure; *11677.*

Volume; 1.8 to 90 K; Cost; Cryogenic; Efficiency; Mass; Refrigeration; *11457.*

Volume exclusion; Linear polymers; Markov chains; Order-disorder transitions; Random variables; Restricted chains; Theta point; Transition probabilities; *11646.*

Volume relaxation times; Activation energy; Annealing; Arrhenius behavior; B_2O_3 glass; Distribution of relaxation times; Relaxation times; *11674.*

Volume resistivity; Calorimetry; Cryogenics; Dielectric constant; Ferroelectric ceramic; Pyroelectric coefficient; Thermometry; *11037.*

Volume viscosity; Activity coefficients; Binary mixture; Brillouin scattering; Fluctuations; Light scattering from solutions; Rayleigh scattering; Thermal relaxation; *11686.*

Voluntary standards; Consumers; Safety; Standards; *11639.*

Vorticity; Helium II, superfluid; Thermal conductivity; Thermal gradient; Thermal flux; Turbulence; Two-fluid hydrodynamics; *11718.*

Vulcanizates; Compliance; Creep; Dicumyl peroxide vulcanizates; Indentation of rubber; Modulus; Natural; Natural rubber; Rubber; Strain-time relations; *11793.*

Vulcanization; X-ray diffraction; Anisotropic; Beta-naphthyl group; Block polymers; Bonds; Crystallization; Elastomers; Expansivity; Forces; Phenyl-beta-naphthylamine; Stiffening; *11144.*

W

Wall-stabilized arc; Atomic; Infrared lines; Neutral argon; Transition probabilities; *11479.*

Wash-and-wear; Apparel; Care instructions; Labeling, apparel; Performance, apparel; Properties, apparel; Testing textiles; *11492.*

Wash-and-wear textiles; Apparel, textile; Blends, fabric; Care instructions, textiles; Consumer goods, textile; Fabrics, textile; Fibers, textile; Flammability, textile; Glossary, textile; Properties, textile fiber; Textiles; *CIS1.*

Water; Anomalous water; Infrared spectrum of polywater; Polywater; Raman spectrum of polywater; *11048.*

Water; Bulk modulus; Density; Equation of state; High pressure; Velocity of sound; *10983.*

Water; Crystal growth; Cylinder; Ice; Morphological stability; Surface tension; *11321.*

Water; Crystal growth; Cylinder; Ice; Morphological stability; Morphology; *11274.*

Water; Cylinder; Heat flow; Ice; Interfacial free energy; Perturbations; Stability; Surface tension; *10973.*

Water; Cylinder; Heat flow; Ice; Morphology; Perturbations; Stability; Surface tension; *10974.*

Water; Density; Dielectric constant; Excess molar volume; Kirkwood correlation parameter; N-methylpropionamide; Structure; *10988.*

Water; Electron affinity; Negative ion; Photodetachment; *10964.*

Water vapor; Work function; Adsorption; Hydrogen evolution; Polycrystalline tungsten; Room temperature; Ultra-high vacuum; *11563.*

Watson's lemma; Airy integral; Asymptotics; Error bounds; Gamma function; Saddle-points; Steepest descents; *11700.*

Wave field; Wave packet; X-ray diffraction; Atom; Displacement; Distorted crystal; Energy flow; Finite beam; Theory; *11031.*

Wave functions; Electronic density of states; Hyperfine fields; Knight shift; Nuclear magnetic resonance; Susceptibility; **J.74A** *No. 4, 569-610 (1970).*

Wave functions; Energy levels; Oscillator strengths; Superposition of configurations; *11606.*

Wave packet; X-ray diffraction; Atom; Displacement; Distorted crystal; Energy flow; Finite beam; Theory; Wave field; *11031.*

Wave propogation in stochastic media; Crystal dynamics; Defects; Disordered crystals; Multiple scattering; *11439.*

Waveform; Waveguide junction; Admittance; Antenna; Attenuator; Bolometer; Calorimetry; Horn; Impedance; Interferometry; Measuring system; Phase; Power; Radiometry; Resonant cavity; Voltage; *SP300. Volume 4.*

Wavefront shearing interferometer; Aberration of telescopes; Interferometer; Shearing interferometer; Telescopes; *11110.*

Waveguide; Electron; Energy loss; Linear accelerator; Short pulse; Transient beam-loading; *11369.*

Waveguide, adjustable width; Weathering test; Wheel-shaft angle, shifting during rotation; Wind vane, damped; Accelerated weathering test; Acoustic, distortion, cancelling; Averaging wind vane; Cryogen density, measuring; Distortion-cancelling loudspeakers; *TN536.*

Waveguide junction; Admittance; Antenna; Attenuator; Bolometer; Calorimetry; Horn; Impedance; Interferometry;

APPENDIX A. LIST OF DEPOSITORY LIBRARIES IN THE UNITED STATES

ALABAMA

- Alexander City: Alexander City State Junior College Library (1967).
- Auburn: Auburn University, Ralph Brown Draughon Library (1907).
- Birmingham:
  - Birmingham Public Library (1895).
  - Birmingham-Southern College, M. Paul Phillips Library (1932).
  - Samford University, Harwell G. Davis Library (1884).
- Enterprise: Enterprise State Junior College Library (1967).
- Florence: Florence State College, Collier Library (1932).
- Gadsden: Gadsden Public Library (1963).
- Huntsville: University of Alabama, Huntsville Campus Library (1964).
- Jacksonville: Jacksonville State University, Ramona Wood Library (1929).
- Maxwell A. F. Base: Air University Library (1963).
- Mobile:
  - Mobile Public Library (1963).
  - Spring Hill College, Thomas Byrne Memorial Library (1937).
  - University of South Alabama Library (1968).
- Montgomery:
  - Alabama State Department of Archives and History Library (1884).
  - Alabama Supreme Court Library (1884).
- Normal: Alabama Agricultural and Mechanical College, Drake Memorial Library (1963).
- St. Bernard: St. Bernard College Library (1962).
- Troy: Troy State College Library (1963).
- Tuskegee Institute: Tuskegee Institute, Hollis Burke Frissell Library (1907).
- University:
  - University of Alabama Law Library (1967).
  - University of Alabama Library (1860)—REGIONAL.

ALASKA

- Anchorage:
  - Anchorage Community College Library (1961).
  - Anchorage Methodist University Library (1963).
- College: University of Alaska Library (1922).
- Juneau: Alaska State Library (1964).

ARIZONA

- Flagstaff: Northern Arizona University Library (1937).
- Phoenix:
  - Department of Library and Archives (unknown)—REGIONAL.
  - Phoenix Public Library (1917).
- Prescott: Prescott College Library (1968).
- Tempe: Arizona State University, Matthews Library (1944).
- Thatcher: Eastern Arizona Junior College Library (1963).
- Tucson: University of Arizona Library (1907)—REGIONAL.
- Yuma: Yuma City-County Library (1963).

ARKANSAS

- kadelphia: Ouachita Baptist University, Riley Library (1963).
- tesville: Arkansas College Library (1963).
- arksville: College of the Ozarks Library (1925).
- llege Heights: Arkansas Agricultural and Mechanical College Library (1956).
- Conway: Hendrix College, O. C. Bailey Library (1903).
- Fayetteville: University of Arkansas Library (1907).
- Little Rock:
  - Arkansas Supreme Court Library (1962).
  - Little Rock Public Library (1953).
- Magnolia: Southern State College, J. M. Peace Library (1956).
- Russellville: Arkansas Polytechnic College, Tomlinson Library (1925).
- Searcy: Harding College, Beaumont Memorial Library (1963).
- State College: Arkansas State University, Dean B. Ellis Library (1913).
- Walnut Ridge: Southern Baptist College, Felix Goodson Library (1967).

CALIFORNIA

- Anaheim: Anaheim Public Library (1963).
- Arcata: Humboldt State College Library (1963).
- Bakersfield: Kern County Library.
- Berkeley:
  - University of California, General Library (1907).
  - University of California, Law Library, Earl Warren Legal Center (1963).
- Chico: Chico State College Library (1962).
- Claremont: Pomona College Documents Collection, Honnold Library (1913).
- Culver City: Culver City Library (1966).
- Davis: University of California Library (1953).
- Downey: Downey City Library (1963).
- Fresno:
  - Fresno County Free Library (1920).
  - Fresno State College Library (1962).
- Fullerton: California State College at Fullerton Library (1963).
- Gardena: Gardena Public Library (1966).
- Hayward: California State College at Hayward Library (1963).
- Inglewood Public Library (1963).
- Irvine: University of California at Irvine Library (1963).
- La Jolla: University of California, San Diego, University Library (1963).
- Lancaster: Lancaster Regional Library (1967).
- Long Beach:
  - California State College at Long Beach Library (1962).
  - Long Beach Public Library (1933).
- Los Angeles:
  - California State College at Los Angeles, John F. Kennedy Memorial Library (1956).
  - Los Angeles County Law Library (1963).
  - Los Angeles Public Library (1891).
  - Loyola University of Los Angeles Library (1933).
  - Occidental College, Mary Norton Clapp Library (1941).
  - Pepperdine College Library (1963).
  - University of California at Los Angeles Library (1932).
  - University of California, School of Law Library (1958).
  - University of Southern California Library (1933).
- Lynwood: Lynwood Library (1966).
- Marysville: Yuba College Library (1963).
- Menlo Park: Department of the Interior, Geological Survey Library (1962).
- Montebello: Montebello Library (1966).
- Monterey: Naval Postgraduate School Library (1963).
- Monterey Park: Bruggemeyer Memorial Library (1964).
- Newhall: Newhall Library of Los Angeles County Public Library System (1967).
- Northridge: San Fernando Valley State College Library (1958).

Oakland:
    Mills College Library (1966).
    Oakland Public Library (1923).
Orange: Orange County Public Library (1963).
Pasadena:
    California Institute of Technology Library (1933).
    Pasadena Public Library (1963).
Pleasant Hill: Contra Costa County Library (1964).
Redding: Shasta County Library (1956).
Redlands: University of Redlands Library (1933).
Redwood City: Redwood City Public Library (1966).
Reseda: West Valley Regional Branch Library (1966).
Richmond: Richmond Public Library (1943).
Riverside:
    Riverside Public Library (1947).
    University of California at Riverside Library (1963).
Sacramento:
    California State Library (1895)—REGIONAL.
    Sacramento City Library (1880).
    Sacramento County Law Library (1963).
    Sacramento State College Library (1963).
San Bernardino: San Bernardino County Free Library (1964).
San Diego:
    San Diego County Library (1966).
    San Diego Public Library (1895).
    San Diego State College Library (1962).
    University of San Diego Law Library (1967).
San Francisco:
    Mechanics' Institute Library (1889).
    San Francisco Public Library (1889).
    San Francisco State College, Social Science and Business Library (1955).
    University of San Francisco, Richard A. Gleeson Library (1963).
San Jose: San Jose State College Library (1962).
San Leandro: San Leandro Community Library Center (1961).
Santa Ana: Santa Ana Public Library (1959).
Santa Barbara: University of California at Santa Barbara Library (1960).
Santa Clara: University of Santa Clara, Orradre Library (1963).
Santa Cruz: University of California at Santa Cruz Library (1963).
Santa Rosa: Santa Rosa-Sonoma County Public Library (1896).
Stanford: Stanford University Libraries (1895).
Stockton: Public Library of Stockton and San Joaquin County (1884).
Thousand Oaks: California Lutheran College Library (1964).
Torrance: Torrance Public Library (1969).
Turlock: Stanislaus State College Library (1964).
Visalia: Tulare County Free Library (1967).
Walnut: Mount San Antonio College Library (1966).
West Covina: West Covina Library (1966).
Whittier: Whittier College, Wardman Library (1963).

CANAL ZONE

Balboa Heights: Canal Zone Library-Museum (1963).

COLORADO

Alamosa: Adams State College Library (1963).
Boulder: University of Colorado Libraries (1879)—REGIONAL.
Colorado Springs: Colorado College, Charles Leaming Tutt Library (1880).
Denver:
    Colorado State Library (unknown).
    Denver Public Library (1884)—REGIONAL.
    Department of Interior, Bureau of Reclamation Library (1962).
    Regis College, Dayton Memorial Library (1915).
    University of Denver, Mary Reed Library (1909).
Fort Collins: Colorado State University Library (1907).
Golden:
    Colorado School of Mines, Arthur Lakes Library (1939).
    Jefferson County Public Library (1968).
Greeley: Colorado State College Library (1966).
Gunnison: Western State College, Leslie J. Savage Library (1932).
La Junta: Otero Junior College, Wheeler Library (1963).
Pueblo:
    McClelland Public Library (1893).
    Southern Colorado State College Library (1965).
U.S. Air Force Academy: Academy Library (1956).

CONNECTICUT

Bridgeport: Bridgeport Public Library (1884).
Danbury: Western Connecticut State College Library (1967).
Hartford:
    Connecticut State Library (unknown)—REGIONAL.
    Hartford Public Library (1945).
    Trinity College Library (1895).
Middletown: Wesleyan University, Olin Library (1906).
Mystic: Mystic Seaport Library (1964).
New Haven:
    Southern Connecticut State College Library (1968).
    Yale University Library (1859).
New London:
    Connecticut College Library (1926).
    U.S. Coast Guard Academy Library (1939).
Pomfret: Pomfret School Library (1968).
Storrs: University of Connecticut, Wilbur Cross Library (1907).
Thompsonville: Enfield Public Library (1967).
Waterbury: Silas Bronson Library (1869).

DELAWARE

Dover:
    Delaware State College, William C. Jason Library (1962).
    State Law Library in Kent County (unknown).
Georgetown: Delaware Technical and Community College, Southern Branch Library (1968).
Newark: University of Delaware, Morris Library (1907).
Wilmington: Wilmington Institute Free Library (1861).

DISTRICT OF COLUMBIA

Washington:
    Bureau of the Budget Library, Executive Office of the President (1965).
    Civil Service Commission Library (1963).
    Department of Commerce Library (1955).
    Department of Health, Education, and Welfare Library (1954).
    Department of the Interior Central Library (1895).
    Department of the Interior, Geological Survey Library (1962).
    Department of Justice, Main Library (1895).
    Department of State Library (1895).
    Department of State, Office of Legal Advisor, Law Library (1966).
    Department of Transportation, National Highway Safety Bureau Library (1968).
    District of Columbia Public Library (1943).
    Georgetown University Library (1969).
    Indian Claims Commission Library (1968).
    National Agricultural Library (1895).
    National War College Library (1895).
    Navy Department Library (1895).

  - Navy Department, Office of Judge Advocate General Library (1963).
  - Post Office Department Library (1895).
  - Treasury Department Library (1895).
  - Veterans Administration, Medical and General Reference Library (1967).

FLORIDA

- Boca Raton: Florida Atlantic University Library (1963).
- Coral Gables: University of Miami Library (1939).
- Daytona Beach: Volusia County Public Libraries (1963).
- De Land: Steston University, DuPont-Ball Library (1887).
- Fort Lauderdale:
  - Fort Lauderdale Public Library (1967).
  - Nova University Library (1967).
- Gainesville: University of Florida Libraries (1907)—REGIONAL.
- Jacksonville:
  - Haydon Burns Library (1914).
  - Jacksonville University, Swisher Library (1962).
- Lakeland: Lakeland Public Library (1928).
- Leesburg: Lake-Sumter Junior College Library (1963).
- Melbourne: Florida Institute of Technology Library (1963).
- Miami:
  - Miami Dade Junior College, North Campus Library (1967).
  - Miami Public Library (1952).
- Milton: Aeronautical Systems Library (1969).
- Opa Locka: Biscayne College Library (1966).
- Orlando: Florida Technological University Library (1966).
- Palatka: St. Johns River Junior College Library (1963).
- Pensacola: University of West Florida Library (1966).
- St. Petersburg: St. Petersburg Public Library (1965).
- Tallahassee:
  - Florida Agricultural and Mechanical University, Coleman Memorial Library (1936).
  - Florida State Library (1929).
  - Florida State University, R. M. Strozier Library (1941).
- Tampa:
  - Tampa Public Library (1965).
  - University of South Florida Library (1962).
  - University of Tampa Library (1953).
- Winter Park: Rollins College, Mills Memorial Library (1909).

GEORGIA

- Albany: Albany Public Library (1964).
- Americus: Georgia Southwestern College, Wade Lott Memorial Library (1966).
- Athens: University of Georgia Libraries (1907).
- Atlanta:
  - Atlanta Public Library (1880).
  - Atlanta University, Trevor Arnett Library (1962).
  - Emory University, Asa Griggs Candler Library (1928).
  - Emory University, School of Law Library (1968).
  - Georgia Institute of Technology, Price Gilbert Memorial Library (1963).
  - Georgia State Library (unknown).
- Augusta: Augusta College Library (1962).
- Brunswick: Brunswick Public Library (1965).
- Carrollton: West Georgia College, Sanford Library (1962).
- Dahlonege: North Georgia College Library (1939).
- Gainesville: Chestatee Regional Library (1968).
- Macon: Mercer University Library (1964).
- Marietta: Kennesaw Junior College Library (1968).
- Milledgeville: Georgia College at Milledgeville, Ina Dillard Russell Library (1950).
- Savannah: Savannah Public and Chatham-Effingham-Liberty Regional Library (1857).
- Statesboro: Georgia Southern College, Rosenwald Library (1939).
- Valdosta: Valdosta State College, Richard Holmes Powell Library (1956).

GUAM

- Agana: Nieves M. Flores Memorial Library (1962).

HAWAII

- Hilo: University of Hawaii, Hilo Campus Library (1962).
- Honolulu:
  - Chaminade College of Honolulu Library (1965).
  - Hawaii Medical Library, Inc. (1968).
  - Hawaii State Library (1929).
  - Municipal Reference Library of the City and County of Honolulu (1965).
  - University of Hawaii Library (1907).
- Laie: Church College of Hawaii Library (1964).
- Lihue: Kauai Public Library (1967).
- Pearl City: Leeward Community College Library (1967).
- Wailuku: Maui Public Library (1962).

IDAHO

- Boise:
  - Boise State College Library (1966).
  - Boise Public Library (1929).
  - Idaho State Law Library (unknown).
- Caldwell: College of Idaho, Terteling Library (1930).
- Moscow: University of Idaho Library (1907)—REGIONAL.
- Pocatello: Idaho State University Library (1908).
- Rexburg: Ricks College, David O. McKay Library (1946).

ILLINOIS

- Bloomington: Illinois Wesleyan University Libraries (1964).
- Carbondale: Southern Illinois University Library (1932).
- Carlinville: Blackburn College Library (1954).
- Champaign: University of Illinois Law Library, College of Law (1965).
- Charleston: Eastern Illinois University, Booth Library (1962).
- Chicago:
  - Chicago Natural History Museum Library (1963).
  - Chicago Public Library (1876).
  - Chicago State College Library (1954).
  - John Crerar Library (1909).
  - Loyola University, E. M. Cudahy Memorial Library (1966).
  - Newberry Library (1890).
  - Northeastern Illinois State College Library (1961).
  - University of Chicago Law Library (1964).
  - University of Chicago Library (1897).
  - University of Illinois, Chicago Circle Campus Library (1957).
- Decatur: Decatur Public Library (1954).
- De Kalb: Northern Illinois University, Swen Franklin Parson Library (1960).
- Edwardsville: Southern Illinois University, Lovejoy Memorial Library (1959).
- Elsah: Principia College, Marshall Brooks Library (1957).
- Evanston: Northwestern University Library (1876).
- Freeport: Freeport Public Library (1905).
- Galesburg: Galesburg Public Library (1896).
- Jacksonville: MacMurry College, Henry Pfeiffer Library (1929).
- Kankakee: Olivet Nazarene College, Memorial Library (1946).

Lake Forest: Lake Forest College, Donnelley Library (1962).
Lebanon: McKendree College, Holman Library (1968).
Lisle: St. Procopius College Library (1911).
Lockport: Lewis College of Science and Technology Library (1952).
Macomb: Western Illinois University Memorial Library (1962).
Monmouth: Monmouth College Library (1860).
Normal: Illinois State University, Milner Library (1877).
Oak Park: Oak Park Public Library (1963).
Peoria:
    Bradley University Library (1963).
    Peoria Public Library (1883).
River Forest: Rosary College Library (1966).
Rock Island: Rock Island Public Library (1950).
Rockford: Rockford Public Library (unknown).
Springfield: Illinois State Library (unknown)–REGIONAL.
Urbana: University of Illinois Library (1907).
Wheaton: Wheaton College Library (1964).
Woodstock: Woodstock Public Library (1963).

INDIANA

Anderson: Anderson College, Charles E. Wilson Library (1959).
Bloomington: Indiana University Library (1881).
Crawfordsville: Wabash College, Lilly Library (1906).
Evansville:
    Evansville and Vanderburgh County Public Library (1928).
    Indiana State University, Evansville Campus Library (1969).
Fort Wayne:
    Indiana-Purdue Universities, Regional Campus Library (1965).
    Public Library of Fort Wayne and Allen County (unknown).
Gary:
    Gary Public Library (1943).
    Indiana University, Northwest Campus Library (1966).
Greencastle: De Pauw University, Roy O. West Library (1879).
Hammond: Hammond Public Library (1964).
Hanover: Hanover College Library (1892).
Huntington: Huntington College Library (1964).
Indianapolis:
    Butler University, Irwin Library (1965).
    Indiana State Library (unknown)–REGIONAL.
    Indiana University, Law Library (1967).
    Indianapolis Public Library (1906).
Jeffersonville: Indiana University, Southeastern Campus Library (1965).
Kokomo: Indiana University, Kokomo Regional Campus Library (1969).
Lafayette: Purdue University Library (1907).
Muncie:
    Ball State University Library (1959).
    Muncie Public Library (1906).
Notre Dame: University of Notre Dame, Memorial Library (1883).
Rensselaer: St. Joseph's College Library (1964).
Richmond:
    Earlham College, Lilly Library (1964).
    Morrison-Reeves Library (1906).
South Bend: Indiana University, South Bend-Mishawaka Campus Library (1965).
Terre Haute: Indiana State University, Cunningham Memorial Library (1906).
Valparaiso: Valparaiso University, Moellering Memorial Library (1930).

IOWA

Ames: Iowa State University of Science and Technology Library (1907).
Cedar Falls: University of Northern Iowa Library (1946).
Council Bluffs: Free Public Library (1885).
Denison: Midwestern College Library (1967).
Des Moines:
    Drake University, Cowles Library (1966).
    Iowa State Traveling Library (unknown).
    Public Library of Des Moines (1888).
Dubuque:
    Carnegie-Stout Public Library (unknown).
    Loras College Wahlert Memorial Library (1967).
Fairfield: Parsons College Library Branch of Fairfield Public Library (1862).
Grinnell: Grinnell College Library (1874).
Iowa City:
    University of Iowa, Law Library (1968).
    University of Iowa Library (1884)–REGIONAL.
Lamoni: Graceland College, Frederick Madison Smith Library (1927).
Mount Vernon: Cornell College, Russell D. Cole Library (1896).
Sioux City: Sioux City Public Library (1894).

KANSAS

Atchison: St. Benedict's College, the Abbey Library (1965).
Baldwin City: Baker University Library (1908).
Colby: Colby Community Junior College Library (1968).
Emporia: Kansas State Teachers College, William Allen White Library (1909).
Hays: Fort Hays Kansas State College, Forsyth Library (1926).
Hutchinson: Hutchinson Public Library (1963).
Lawrence: University of Kansas, Watson Library (1869).
Manhattan: Kansas State University, Farrell Library (1907).
Pittsburg: Kansas State College of Pittsburg, Porter Library (1952).
Salina: Kansas Wesleyan University Library (1930).
Topeka:
    Kansas State Historical Society Library (1877).
    State Libraries of Kansas (unknown).
Wichita: Wichita State University Library (1901).

KENTUCKY

Ashland: Ashland Public Library (1946).
Barbourville: Union College, Abigail E. Weeks Memorial Library (1958).
Bowling Green: Western Kentucky University, Margie Helm Library (1934).
Danville: Centre College, Grace Doherty Library (1884).
Frankfort:
    Kentucky Department of Libraries (1967).
    State Law Library (unknown).
Lexington:
    University of Kentucky, Law Library (1968).
    University of Kentucky, Margaret I. King Library (1907)–REGIONAL.
Louisville:
    Louisville Free Public Library (1904).
    University of Louisville Library (1925).
Morehead: Morehead State University, Johnson Camden Library (1955).
Murray: Murray State University Library (1924).
Owensboro: Kentucky Wesleyan College Library (1966).
Pikeville: Pikeville College Library (1947).
Richmond: Eastern Kentucky University, John Grant Crabbe Library (1966).

LOUISIANA

Baton Rouge:
  Louisiana State University Law Library (1929).
  Louisiana State University Library (1907)—REGIONAL.
  Southern University Library (1952).
Eunice: Louisiana State University at Eunice, LeDoux Library (1969).
Hammond: Southeastern Louisiana College, Sims Memorial Library (1966).
Lafayette: University of Southwestern Louisiana Library (1938).
Lake Charles: McNeese State College, Frazar Memorial Library (1941).
Monroe: Northeast Louisiana State College, Sandel Library (1963).
Natchitoches: Northwestern State College of Louisiana, Russell Library (1887).
New Orleans:
  Isaac Delgado College, Moss Technical Library (1968).
  Law Library of Louisiana (unknown).
  Louisiana State University in New Orleans Library (1963).
  Loyola University Library (1942).
  New Orleans Public Library (1883).
  Southern University in New Orleans Library (1962).
  Tulane University, Howard-Tilton Memorial Library (1942).
Pineville: Louisiana College, Richard W. Norton Memorial Library (1969).
Ruston: Louisiana Polytechnic Institute Library (1896)—REGIONAL.
Shreveport:
  Louisiana State University at Shreveport Library (1967).
  Shreve Memorial Library (1923).
Thibodaux: Francis T. Nicholls State College, Leonidas Polk Library (1962).

MAINE

Augusta: Maine State Library (unknown).
Bangor: Bangor Public Library (1884).
Brunswick: Bowdoin College, Hawthorne-Longfellow Library (1884).
Lewiston: Bates College Library (1883).
Orono: University of Maine, Raymond H. Fogler Library (1907)—REGIONAL.
Portland:
  Portland Public Library (1884).
  University of Maine Law Library (1964).
Springvale: Nasson College Library (1961).
Waterville: Colby College Library (1884).

MARYLAND

Annapolis:
  Maryland State Library (unknown).
  U.S. Naval Academy Library (1895).
Baltimore:
  Enoch Pratt Free Library (1887).
  Johns Hopkins University, Milton S. Eisenhower Library (1882).
  Morgan State College Library (1940).
Bel Air: Harford Junior College Library (1967).
Bethesda: Montgomery County Department of Public Libraries (1951).
Chestertown: Washington College, George Avery Bunting Library (1891).
College Park: University of Maryland, McKeldin Library (1925)—REGIONAL.
Frostburg: Frostburg State College, Jerome Frampton Library (1967).
Germantown: Atomic Energy Commission Library (1963).
Patuxent River: Naval Air Station Library (1968).
Salisbury: Salisbury State College, Blackwell Library (1965).
Towson: Groucher College, Julia Rogers Library (1966).
Westminster: Western Maryland College Library (1896).

MASSACHUSETTS

Amherst:
  Amherst College Library (1884).
  University of Massachusetts, Goodell Library (1907).
Belmont: Belmont Memorial Library (1968).
Boston:
  Boston Athenaeum Library (unknown).
  Boston College, Bapst Library (1963).
  Boston Public Library (1859).
  Northeastern University, Dodge Library (1962).
  State Library of Massachusetts (unknown)—REGIONAL
Brookline: Public Library of Brookline (1925).
Cambridge:
  Harvard College Library (1860).
  Massachusetts Institute of Technology Libraries (1946).
Chicopee: Our Lady of the Elms College Library (1969).
Lowell: Lowell Technological Institute Library (1952).
Lynn: Lynn Public Library (1953).
Medford: Tufts University Library (1899).
New Bedford: New Bedford Free Public Library (1858).
North Dartmouth: Southeastern Massachusetts Technological Institute Library (1965).
North Easton: Stonehill College, Cushing-Martin Library (1962).
Springfield: Springfield City Library (1966).
Waltham: Brandeis University, Goldfarb Library (1965).
Wellesley: Wellesley College Library (1943).
Wenham: Gordon College, Winn Library (1963).
Williamstown: Williams College Library (unknown).
Worcester:
  American Antiquarian Society Library (1814).
  Worcester Public Library (1859).

MICHIGAN

Albion: Albion College, Stockwell Memorial Library (1966).
Allendale: Grand Valley State College Library (1963).
Alma: Alma College, Monteith Library (1963).
Ann Arbor: University of Michigan, General Library (1884).
Battle Creek: Willard Library (1876).
Benton Harbor: Benton Harbor Public Library (1907).
Bloomfield Hills: Granbrook Institute of Science Library (1940).
Dearborn: Henry Ford Community College Library (1957).
Detroit:
  Detroit Public Library (1868)—REGIONAL.
  Marygrove College Library (1965).
  Mercy College of Detroit Library (1965).
  University of Detroit Library (1884).
  Wayne County Public Library (1957).
  Wayne State University Library (1937).
East Lansing: Michigan State University Library (1907).
Escanaba: Michigan State Library, Upper Peninsula Branch (1964).
Farmington: Martin Luther King Learning Resources Center, Oakland Community College (1968).
Flint:
  Charles Stewart Mott Library (1959).
  Flint Public Library (1967).
Grand Rapids:
  Grand Rapids Public Library (1876).
  Knollcrest Calvin Library (1967).

Houghton: Michigan Technological University Library (1876).
Jackson: Jackson Public Library (1965).
Kalamazoo:
  Kalamazoo Library System (1907).
  Western Michigan University, Dwight B. Waldo Library (1963).
Lansing: Michigan State Library (unknown)—REGIONAL.
Livonia: Schoolcraft College Library (1962).
Marquette: Northern Michigan University, Olsen Library (1963).
Mt. Clemens: Macomb County Library (1968).
Mt. Pleasant: Central Michigan University Library (1958).
Muskegon: Hackley Public Library (1894).
Petoskey: North Central Michigan College Library (1962).
Port Huron: Saint Clair County Library System (1876).
Rochester: Oakland University, Kresge Library (1964).
Saginaw: Hoyt Public Library (1890).
Traverse City: Northwestern Michigan College, Mark Osterlin Library (1964).
University Center: Delta College Library (1963).
Ypsilanti: Eastern Michigan University Library (1965).

MINNESOTA

Bemidji: Bemidji State College Library (1963).
Collegeville: St. John's University, Alcuin Library (1954).
Duluth: Duluth Public Library (1909).
Mankato: Mankato State College Library (1962).
Minneapolis:
  Minneapolis Public Library (1893).
  University of Minnesota, Wilson Library (1907)—REGIONAL.
Moorhead: Moorhead State College Library (1956).
Morris: University of Minnesota at Morris Library (1963).
Northfield:
  Carleton College Library (1930).
  St. Olaf College, Rolvaag Memorial Library (1930).
St. Cloud: St. Cloud State College Library (1962).
St. Paul:
  Minnesota Historical Society Library (1867).
  Minnesota State Law Library (unknown).
  St. Paul Public Library (1914).
Saint Peter: Gustavus Adolphus College Library (1941).
Stillwater: Stillwater Public Library (1893).
Wilmar: Kandiyohi County-Willmar Library (1958).
Winona: Winona State College, Maxwell Library (1969).

MISSISSIPPI

Columbus: Mississippi State College for Women, J. C. Fant Memorial Library (1929).
Hattiesburg: University of Southern Mississippi Library (1935).
Jackson:
  Jackson State College Library (1968).
  Millsaps College, Millsaps-Wilson Library (1963).
  Mississippi Library Commission (1947).
  Mississippi State Law Library (unknown).
State College: Mississippi State University, Mitchell Memorial Library (1907).
University:
  University of Mississippi Library (1883).
  University of Mississippi, School of Law Library (1967).

MISSOURI

Cape Girardeau: Southeast Missouri State College, Kent Library (1916).
Columbia: University of Missouri Library (1862).
Fayette: Central Methodist College Library (1962).
Fulton: Westminster College, Reeves Library (1875).
Hannibal: Hannibal Free Public Library (1909).
Jefferson City:
  Lincoln University, Inman E. Page Library (1944).
  Missouri State Library (1963).
  Missouri Supreme Court Library (unknown).
Joplin: Missouri Southern State College Library (1966).
Kansas City:
  Kansas City Public Library (1881).
  Rockhurst College Library (1917).
  University of Missouri at Kansas City, General Library (1938).
Kirksville: Northeast Missouri State Teachers College, Pickler Memorial Library (1966).
Liberty: William Jewell College Library (1900).
Rolla: University of Missouri at Rolla Library (1907).
St. Joseph: St. Joseph Public Library (1891).
St. Louis:
  St. Louis Public Library (1866).
  St. Louis University, Law Library (1967).
  St. Louis University, Pius XII Memorial Library (1866).
  University of Missouri at St. Louis Library (1966).
  Washington University, John M. Olin Library (1906).
Springfield:
  Drury College Library (1874).
  Southwest Missouri State College Library (1963).
Warrensburg: Central Missouri State College, Ward Edwards Library (1914).

MONTANA

Billings: Eastern Montana College Library (1924).
Bozeman: Montana State University Library (1907).
Butte: Montana College of Mineral Science and Technology Library (1901).
Helena:
  Montana Historical Society Library (unknown).
  Montana State Library (1966).
Missoula: University of Montana Library (1909)—REGIONAL.

NEBRASKA

Blair: Dana College Library (1924).
Crete: Doane College, Whitin Library (1944).
Fremont: Midland Lutheran College Library (1924).
Kearney: Kearney State College, Calvin T. Ryan Library (1962).
Lincoln:
  Nebraska State Library (unknown).
  University of Nebraska, Don L. Love Memorial Library (1907).
Omaha:
  Creighton University, Alumni Library (1964).
  Omaha Public Library (1880).
  University of Omaha, Gene Eppley Library (1939).
Scottsbluff: Scottsbluff Public Library (1925).

NEVADA

Carson City: Nevada State Library (unknown).
Las Vegas: Nevada Southern University, James R. Dickinson Library (1959).
Reno: University of Nevada Library (1907)—REGIONAL.

NEW HAMPSHIRE

Concord: New Hampshire State Library (unknown).
Durham: University of New Hampshire Library (1907).
Hanover: Dartmouth College, Baker Library (1884).
Henniker: New England College Library (1966).

- Manchester:
  - Manchester City Library (1884).
  - St. Anselm's College, Geisel Library (1963).

NEW JERSEY

- Atlantic City: Atlantic City Free Public Library (1908).
- Bayonne: Bayonne Free Public Library (1909).
- Bloomfield: Free Public Library of Bloomfield (1965).
- Bridgeton: Cumberland County Library (1966).
- Camden: Rutgers Library in South Jersey (1966).
- Convent Station: College of St. Elizabeth, Santa Maria Library (1938).
- East Orange: East Orange Public Library (1966).
- Elizabeth: Free Public Library of Elizabeth (1895).
- Glassboro: Glassboro State College, Savitz Library (1963).
- Hackensack: Johnson Free Public Library (1966).
- Irvington: Free Public Library of Irvington (1966).
- Jersey City:
  - Jersey City Free Public Library (1879).
  - Jersey City State College, Forrest A. Irwin Library (1963).
- Madison: Drew University, Rose Memorial Library (1939).
- Mount Holly: Burlington County Area Library (1966).
- New Brunswick:
  - Free Public Library (1908).
  - Rutgers University Library (1907).
- Newark:
  - Newark Public Library (1906)—REGIONAL.
  - Rutgers—The State University, John Cotton Dana Library (1966).
- Passaic: Passaic Public Library (1964).
- Princeton: Princeton University Library (1884).
- Rutherford: Fairleigh Dickinson University, Periodicals Library (1953).
- Shrewsbury: Monmouth County Library (1968).
- South Orange: Seton Hall University Library (1947).
- Teaneck: Fairleigh Dickinson University, Teaneck Campus Library (1963).
- Toms River: Ocean County College Library (1966).
- Trenton:
  - New Jersey State Library, Law and Reference Bureau, Department of Education (unknown).
  - Trenton Free Public Library (1902).
- Upper Montclair: Montclair State College, Harry A. Sprague Library (1967).
- West Long Branch: Monmouth College, Guggenheim Memorial Library (1963).
- West New York: West New York Free Public Library (1963).
- Woodbridge: Free Public Library of Woodbridge (1965).

NEW MEXICO

- Albuquerque: University of New Mexico, Zimmerman Library (1896)—REGIONAL.
- Hobbs: New Mexico Junior College, Pannell Library (1969).
- Las Cruces: New Mexico State University Library (1907).
- Las Vegas: New Mexico Highlands University, Donnelly Library (1913).
- Portales: Eastern New Mexico University Library (1962).
- Santa Fe:
  - New Mexico State Library (1960)—REGIONAL.
  - Supreme Court Law Library (unknown).

NEW YORK

- Albany:
  - New York State Library (unknown)—REGIONAL.
  - State University of New York at Albany Library (1964).
- Binghamton: State University of New York at Binghamton Library (1962).
- Brockport: State University of New York, Drake Memorial Library (1967).
- Bronx: Herbert H. Lehman College Library (1967).
- Bronxville: Sarah Lawrence College Library (1969).
- Brooklyn:
  - Brooklyn College Library (1936).
  - Brooklyn Public Library (1908).
  - Polytechnic Institute of Brooklyn, Spicer Library (1963).
  - Pratt Institute Library (1891).
  - State University of New York, Downstate Medical Center Library (1958).
- Buffalo:
  - Buffalo and Erie County Public Library (1895).
  - State University of New York at Buffalo, Lockwood Memorial Library (1963).
- Canton: St. Lawrence University, Owen D. Young Library (1920).
- Corning: Corning Community College, Arthur A. Houghton, Jr. Library (1963).
- Cortland: State University of New York, College at Cortland, Memorial Library (1964).
- Elmira: Elmira College, Hamilton Library (1956).
- Farmingdale: State University of New York at Farmingdale Library (1917).
- Flushing: Queens College, Paul Klapper Library (1939).
- Garden City:
  - Adelphia University, Swirbul Library (1966).
  - Nassau Library System (1965).
- Geneseo: State University College, Milne Library (1967).
- Greenvale: C. W. Post College Library (1964).
- Hamilton: Colgate University Library (1902).
- Hempstead: Hofstra University Library (1964).
- Huntington: Huntington Public Library (1966).
- Ithaca:
  - Cornell University Library (1907).
  - New York State Colleges of Agriculture and Home Economics, Albert R. Mann Library (1943).
- Jamaica:
  - Queens Borough Public Library (1926).
  - St. John's University Library (1956).
- Kings Point: U.S. Merchant Marine Academy Library (1962).
- Mount Vernon: Mount Vernon Public Library (1962).
- New Paltz: State University College Library (1965).
- New York City:
  - City University of New York, City College Library (1884).
  - College of Insurance, Ecker Library (1965).
  - Columbia University Libraries (1882).
  - Cooper Union Library (1930).
  - Fordham University Library (1937).
  - New York Law Institute Library (1909).
  - New York Public Library (Astor Branch) (1907).
  - New York Public Library (Lenox Branch) (1884).
  - New York University Libraries (1967).
  - New York University, University Heights Gould Memorial Library (1902).
  - State University of New York, Maritime College Library (1947).
- Newburgh: Newburgh Free Library (1909).
- Oakdale: Dowling College Library (1965).
- Oneonta: State University College, James M. Milne Library (1966).
- Oswego: State University College, Penfield Library (1966).
- Plattsburgh: State University College, Benjamin F. Feinberg Library (1967).
- Potsdam:
  - Clarkson College of Technology, Harriet Call Burnap Memorial Library (1938).
  - State University College Library (1964).
- Poughkeepsie: Vassar College Library (1943).

- Purchase: State University of New York, College at Purchase Library (1969).
- Rochester:
  - Rochester Public Library (1963).
  - University of Rochester Library (1880).
- St. Bonaventure: St. Bonaventure College, Friedsam Memorial Library (1938).
- Saratoga Springs: Skidmore College Library (1964).
- Schenectady: Union College, Schaffer Library (1901).
- Staten Island (Grymes Hill): Wagner College, Horrmann Library (1953).
- Stony Brook: State University of New York at Stony Brook Library (1963).
- Syracuse: Syracuse University Library (1878).
- Troy: Troy Public Library (1869).
- Utica: Utica Public Library (1885).
- West Point: U.S. Military Academy Library (unknown).
- Yonkers: Yonkers Public Library (1910).

NORTH CAROLINA

- Asheville: University of North Carolina at Asheville, D. Hiden Ramsey Library (1965).
- Boone: Appalachian State University, Dauphin Disco Dougherty Library (1963).
- Buies Creek: Campbell College, Carrie Rich Memorial Library (1965).
- Chapel Hill: University of North Carolina Library (1884)—REGIONAL.
- Charlotte:
  - Public Library of Charlotte and Mecklenburg County (1964).
  - Queens College, Everett Library (1927).
  - University of North Carolina at Charlotte, Atkins Library (1964).
- Cullowhee: Western Carolina University, Hunter Library (1953).
- Davidson: Davidson College, Hugh A. & Jane Grey Memorial Library (1893).
- Durham: Duke University Library (1890).
- Greensboro:
  - North Carolina Agricultural and Technical State University, F. D. Bluford Library (1937).
  - University of North Carolina at Greensboro, Walter Clinton Jackson Library (1963).
- Greenville: East Carolina University, J. Y. Joyner Library (1951).
- Laurinburg: St. Andrews Presbyterian College, DeTamble Library (1969).
- Mars Hill: Mars Hill College, Memorial Library (1967).
- Murfreesburo: Chowan College Library (1963).
- Pembroke: Pembroke State College Library (1956).
- Raleigh:
  - North Carolina State Library (unknown).
  - North Carolina State University, D. H. Hill Library (1923).
- Rocky Mount: North Carolina Wesleyan College Library (1969).
- Salisbury: Catawba College Library (1925).
- Wilmington: University of North Carolina at Wilmington, William M. Randall Library (1965).
- Wilson: Atlantic Christian College, Clarence L. Hardy Library (1930).
- Winston-Salem:
  - Forsyth County Public Library System (1954).
  - Wake Forest University, Z. Smith Reynolds Library (1902).

NORTH DAKOTA

- Bismarck:
  - North Dakota State Historical Society Library (1907).
  - North Dakota State Law Library (unknown).
  - Veterans Memorial Public Library (1967).
- Dickinson: Dickinson State College Library (1968).
- Fargo:
  - Fargo Public Library (1964).
  - North Dakota State University Library (1907)—REGIONAL, in cooperation with University of North Dakota, Chester Fritz Library at Grand Forks.
- Grand Forks: University of North Dakota, Chester Fritz Library (1890).
- Minot: Minot State College, Memorial Library (1925).
- Richardton: Assumption College, Abbey Library (1965).
- Valley City: State College Library (1913).

OHIO

- Ada: Ohio Northern University, J. P. Taggart Law Library (1965).
- Akron:
  - Akron Public Library (1952).
  - University of Akron Library (1963).
- Alliance: Mount Union College Library (1888).
- Ashland: Ashland College Library (1938).
- Athens: Ohio University Library (1886).
- Bluffton: Bluffton College, Musselman Library (1951).
- Bowling Green: Bowling Green State University Library (1933).
- Chillicothe: Ohio University at Chillicothe Library (1968).
- Cincinnati:
  - Public Library of Cincinnati and Hamilton County (1884).
  - University of Cincinnati Library (1929).
- Cleveland:
  - Case Western Reserve University, Freiberger Libary (1913).
  - Cleveland Public Library (1886).
  - Cleveland State University Library (1966).
  - John Carroll University, Grasselli Library (1963).
- Columbus:
  - Capital University Library (1968).
  - Columbus Public Library (1885).
  - Ohio State Library (unknown)—REGIONAL.
  - Ohio State University Library (1907).
- Dayton:
  - Dayton and Montgomery County Public Library (1909).
  - University of Dayton, Albert Emanuel Library (1969).
  - Wright State University Library (1965).
- Delaware: Ohio Wesleyan University, L. A. Beeghly Library (1845).
- Elyria: Elyria Public Library (1966).
- Findlay: Findlay College, Shafer Library (1969).
- Gambier: Kenyon College Library (1873).
- Granville: Denison University Library (1884).
- Hiram: Hiram College, Teachout-Price Memorial Library (1874).
- Kent: Kent State University Library (1962).
- Mansfield: Ohio State University, Mansfield Campus Library (1969).
- Marietta: Marietta College, Dawes Memorial Library (1884).
- New Concord: Muskingum College Library (1966).
- Oberlin: Oberlin College Library (1858).
- Oxford: Miami University, Alumni Library (1909).
- Portsmouth: Portsmouth Public Library (unknown).
- Rio Grande: Rio Grande College, Jeanette Albiez Davis Library (1966).
- Springfield: Warder Public Library (1884).
- Steubenville: Public Library of Steubenville and Jefferson County (1950).
- Tiffin: Heidelberg College, Beeghly Library (1964).
- Toledo:
  - Toledo Public Library (1884).
  - University of Toledo Library (1963).
- Van Wert: Brumback Library of Van Wert County (1900).
- Westerville: Otterbein College, Centennial Library (1967).

Wooster: College of Wooster, the Andrews Library (1966).
Youngstown: Public Library of Youngstown and Mahoning County (1923).

OKLAHOMA

Ada: East Central State College, Linscheid Library (1914).
Alva: Northwestern State College Library (1907).
Bartlesville: Bureau of Mines, Petroleum Research Center Library (1962).
Durant: Southeastern State College Library (1929).
Edmond: Central State College Library (1934).
Enid: Public Library of Enid and Garfield County (1908).
Langston: Langston University, G. Lamar Harrison Library (1941).
Norman: University of Oklahoma Libraries (1893).
Oklahoma City:
  Oklahoma City University Library (1963).
  Oklahoma Department of Libraries (1893)—REGIONAL.
Shawnee: Oklahoma Baptist University Library (1933).
Stillwater: Oklahoma State University Library (1907).
Tahlequah: Northeastern State College, John Vaughan Library (1923).
Tulsa:
  Tulsa City-County Library Commission (1963).
  University of Tulsa, McFarlin Library (1929).
Weatherford: Southwestern State College Library (1958).

OREGON

Ashland: Southern Oregon College Library (1953).
Corvallis: Oregon State University Library (1907).
Eugene: University of Oregon Library (1883).
Forest Grove: Pacific University Library (1897).
La Grande: Eastern Oregon College Library (1954).
McMinnville: Linfield College, Northup Library (1965).
Monmouth: Oregon College of Education Library (1967).
Portland:
  Department of the Interior, Bonneville Power Administration Library (1962).
  Lewis and Clark College Library (1967).
  Library Association of Portland (1884).
  Portland State College Library (1963).
  Reed College Library (1912).
Salem:
  Oregon State Library (unknown).
  Willamette University Library (1969).

PENNSYLVANIA

Allentown: Muhlenberg College Library (1939).
Bethlehem: Lehigh University Library (1876).
Bradford: Carnegie Public Library (1909).
Carlisle: Dickinson College Library (1947).
Cheyney: Cheyney State College, Leslie Pinckney Hill Library (1947).
Collegeville: Ursinus College Library (1963).
East Stroudsburg: East Stroudsburg State College, Kemp Library (1966).
Erie: Erie Public Library (1897).
Greenville: Thiel College, Langenheim Memorial Library (1963).
Harrisburg: Pennsylvania State Library (unknown)—REGIONAL.
Haverford: Haverford College Library (1897).
Hazleton: Hazleton Area Public Library (1964).
Indiana: Indiana University of Pennsylvania, Rhodes R. Stabley Library (1962).
Johnstown: Cambria Public Library (1965).
Lancaster: Franklin and Marshall College, Fackenthal Library (1895).
Lewisburg: Bucknell University, Ellen Clarke Bertrand Library (1963).
Mansfield: Mansfield State College Library (1968).
Meadville: Allegheny College, Reis Library (1907).
Millersville: Millersville State College, Ganser Library (1966).
Monessen: Monessen Public Library (1969).
New Castle: New Castle Free Public Library (1963).
Newtown: Bucks County Community College Library (1968).
Norristown: Montgomery County-Norristown Public Library (1969).
Philadelphia:
  Drexel Institute of Technology Library (1963).
  Free Library of Philadelphia (1897).
  Temple University Library, Serials Records Unit (1947).
  University of Pennsylvania Library (1886).
Pittsburgh:
  Bureau of Mines, Pittsburgh Research Center Library (1962).
  Carnegie Library of Pittsburgh, Allegheny Regional Branch (1924).
  Carnegie Library of Pittsburgh (1895).
  University of Pittsburgh, Hillman Library (1910).
Pottsville: Pottsville Free Public Library (1967).
Reading: Reading Public Library (1901).
Scranton: Scranton Public Library (1895).
Slippery Rock: Slippery Rock State College, Maltby Library (1965).
Swarthmore: Swarthmore College Library (1923).
University Park: Pennsylvania State University Library (1907).
Villanova: Villanova University, School of Law Library (1964).
Warren: Warren Library Association, Warren Public Library (1885).
Washington: Washington and Jefferson College, Memorial Library (1884).
Waynesburg: Waynesburg College Library (1964).
West Chester: West Chester State College, Francis Harvey Green Library (1967).
Wilkes-Barre: King's College Library (1949).
Williamsport: James V. Brown Library of Williamsport and Lycoming County (1922).
York: York Junior College Library (1963).

PUERTO RICO

Mayaguez: University of Puerto Rico, Mayaguez Campus Library (1928).
Ponce: Catholic University of Puerto Rico Library (1966).
Rio Piedras: University of Puerto Rico General Library (1928).

RHODE ISLAND

Kingston: University of Rhode Island Library (1907).
Newport: Naval War College Library (1963).
Providence:
  Brown University, John D. Rockefeller, Jr. Library (unknown).
  Providence College Library (1969).
  Providence Public Library (1884).
  Rhode Island College Library (1965).
  Rhode Island State Library (before 1895).
Warwick: Warwick Public Library (1966).
Westerly: Westerly Public Library (1909).

SOUTH CAROLINA

Charleston:
  Baptist College at Charleston Library (1967).
  College of Charleston Library (1869).
  The Citadel Memorial Library (1962).
Clemson: Clemson University Library (1893).

- Columbia:
  - Benedict College, Starks Library (1969).
  - Columbia College Library (1966).
  - South Carolina State Library (before 1895).
  - University of South Carolina, McKissick Memorial Library (1884).
- Due West: Erskine College, McCain Library (1968).
- Florence: Florence County Library (1967).
- Greenville:
  - Furnam University Library (1962).
  - Greenville County Library (1966).
- Greenwood: Lander College Library (1967).
- Orangeburg: South Carolina State College Library (1953).
- Rock Hill: Winthrop College Library (1896).
- Spartanburg: Spartanburg County Public Library (1967).

SOUTH DAKOTA

- Aberdeen: Northern State College Library (1963).
- Brookings: South Dakota State University, Lincoln Memorial Library (1889).
- Rapid City:
  - Rapid City Public Library (1963).
  - South Dakota School of Mines and Technology Library (1963).
- Sioux Falls:
  - Augustana College, Mikkelsen Library and Learning Resources Center (1969).
  - Carnegie Free Public Library (1903).
- Spearfish: Black Hills State College Library (1942).
- Vermillion: University of South Dakota, I. D. Weeks Library (1889).
- Yankton: Yankton College, Corliss Lay Library (1904).

TENNESSEE

- Chattanooga: Chattanooga Public Library (1907).
- Clarksville: Austin Peay State University Library (1945).
- Jackson: Lambuth College, Luther L. Gobbel Library (1967).
- Jefferson City: Carson-Newman College, Maples Library (1964).
- Johnson City: East Tennessee State University, Sherrod Library (1942).
- Knoxville: University of Tennessee Library (1907).
- Martin: University of Tennessee at Martin Library (1957).
- Memphis:
  - Cossitt Reference Library (1896).
  - Memphis State University, John W. Brister Library (1966).
- Murfreesboro: Middle Tennessee State University Library (1912).
- Nashville:
  - Fisk University Library (1965).
  - Joint University Libraries (1884).
  - Public Library of Nashville and Davidson County (1884).
  - Tennessee State Library and Archives, State Library Division (unknown).
- Sewanee: University of the South, Jesse Ball duPont Library (1873).

TEXAS

- Abilene: Hardin-Simmons University Library (1940).
- Arlington: University of Texas at Arlington Library (1963).
- Austin:
  - Texas State Library (unknown)—REGIONAL.
  - University of Texas Library (1884).
  - University of Texas, Lyndon B. Johnson School of Public Affairs Library (1966).
  - University of Texas, School of Law Library (1965).
- Beaumont: Lamar State College of Technology Library (1957).
- Brownwood: Howard Payne College, Walker Memorial Library (1964).
- Canyon: West Texas State University Library (1928).
- College Station: Texas Agricultural and Mechanical University Library (1907).
- Commerce: East Texas State University Library (1937).
- Corsicana: Navarro Junior College Library (1965).
- Dallas:
  - Bishop College, Zale Library (1966).
  - Dallas Baptist College Library (1967).
  - Dallas Public Library (1900).
  - Southern Methodist University, Fondren Library (1925).
- Denton: North Texas State University Library (1948).
- Edinburg: Pan American College Library (1959).
- El Paso:
  - El Paso Public Library (1906).
  - University of Texas at El Paso Library (1966).
- Fort Worth:
  - Fort Worth Public Library (1905).
  - Texas Christian University, Mary Couts Burnett Library (1916).
- Freeport: Brazosport Junior College Library (1969).
- Galveston: Rosenberg Library (1909).
- Houston:
  - Houston Public Library (1884).
  - Rice University, Fondren Library (1967).
  - University of Houston Library (1957).
- Huntsville: Sam Houston State College, Estill Library (1949).
- Kingsville: Texas Arts and Industries University Library (1944).
- Longview: Nicholson Memorial Public Library (1961).
- Lubbock: Texas Technological College Library (1935)—REGIONAL.
- Marshall: Wiley College, Cole Library (1962).
- Nacogdoches: Stephen F. Austin State College, Paul L. Boynton Library (1965).
- Plainview: Wayland Baptist College, Van Howeling Memorial Library (1963).
- San Angelo: Angelo State University Library (1964).
- San Antonio:
  - San Antonio Public Library, Business and Science Department (1899).
  - St. Mary's University Library (1964).
  - Trinity University Library (1964).
- San Marcos: Southwest Texas State College Library (1955).
- Sherman: Austin College, Arthur Hopkins Library (1963).
- Texarkana: Texarkana College Library (1963).
- Waco: Baylor University Library (1905).
- Wichita Falls: Midwestern University, Moffett Library (1963).

UTAH

- Cedar City: Southern Utah State College Library (1964).
- Ephraim: Snow College Library (1963).
- Logan: Utah State University Library (1907)—REGIONAL.
- Ogden: Weber State College Library (1962).
- Provo: Brigham Young University Library (1908).
- Salt Lake City:
  - University of Utah, Law Library (1966).
  - University of Utah Library (1893).
  - Utah State Library Commission, Documents Library (unknown).

VERMONT

- Burlington: University of Vermont, Bailey Library (1907).
- Johnson: Johnson State College, John Dewey Library (1955).
- Middlebury: Middlebury College, Egbert Starr Library (1884).

Montpelier: Vermont State Library (before 1895).
Northfield: Norwich University Library (1908).
Putney: Windham College, Dorothy Culbertson Marvin Memorial Library (1965).

VIRGIN ISLANDS

Charlotte Amalie (St. Thomas): St. Thomas Public Library (1968).

VIRGINIA

Blacksburg: Virginia Polytechnic Institute, Newman Library (1907).
Bridgewater: Bridgewater College, Alexander Mack Memorial Library (1902).
Charlottesville:
- University of Virginia, Alderman Library (1910)—REGIONAL.
- University of Virginia Law Library (1964).

Danville: Danville Community College Library (1969).
Emory: Emory and Henry College (1884).
Fairfax: George Mason College of the University of Virginia Library (1960).
Fredericksburg: Mary Washington College of the University of Virginia, E. Lee Trinkle Library (1940).
Hampden-Sydney: Hampden-Sydney College, Eggleston Library (1891).
Hollins College: Hollins College, Fishburn Library (1967).
Lexington:
- Virginia Military Institute, Preston Library (1874).
- Washington and Lee University, Cyrus Hall McCormick Library (1910).

Norfolk:
- Armed Forces Staff College Library (1963).
- Norfolk Public Library (1895).
- Old Dominion College, Hughes Memorial Library (1963).

Petersburg: Virginia State College, Johnston Memorial Library (1907).
Quantico: Marine Corps Schools, James Carson Breckinridge Library (1967).
Richmond:
- University of Richmond, Boatwright Memorial Library (1900).
- Virginia State Library (unknown).

Roanoke: Roanoke Public Library (1964).
Salem: Roanoke College Library (1886).
Williamsburg: William and Mary College (1936).

WASHINGTON

Bellingham: Western Washington State College, Wilson Library (1963).
Cheney: Eastern Washington State College Library (1966).
Ellensburg: Central Washington State College Library (1962).
Everett: Everett Public Library (1914).
Olympia: Washington State Library (unknown)—REGIONAL.
Port Angeles: Port Angeles Public Library (1965).
Pullman: Washington State University Library (1907).
Seattle:
- Seattle Public Library (1908).
- University of Washington Library (1890).
- University of Washington, School of Law Library (1969).

Spokane: Spokane Public Library (1910).
Tacoma:
- Tacoma Public Library (1894).
- University of Puget Sound, Collins Memorial Library (1938).

Vancouver: Fort Vancouver Regional Library (1962).
Walla Walla: Whitman College, Penrose Memorial Library (1890).

WEST VIRGINIA

Athens: Concord College Library (1924).
Charleston:
- Kanawha County Public Library (1952).
- West Virginia Department of Archives and History Library (unknown).

Elkins: Davis and Elkins College Library (1913).
Fairmont: Fairmont State College Library (1884).
Glenville: Glenville State College, Robert F. Kidd Library (1966).
Huntington: Marshall University Library (1925).
Institute: West Virginia State College Library (1907).
Morgantown: West Virginia University Library (1907)—REGIONAL.
Salem: Salem College Library.
Weirton: Mary H. Weir Public Library (1963).

WISCONSIN

Appleton: Lawrence University, Samuel Appleton Library (1869).
Beloit: Beloit College Libraries (1888).
Eau Claire: Wisconsin State University, William D. McIntyre Library (1951).
Fond du Lac: Fond du Lac Public Library (1966).
Green Bay: University of Wisconsin at Green Bay Library (1968).
La Crosse:
- La Crosse Public Library (1883).
- Wisconsin State University, Florence Wing Library (1965).

Madison:
- Department of Public Instruction, Division for Library Services, Reference and Loan Library (1965).
- Madison Public Library (1965).
- State Historical Society Library (1870)—REGIONAL, in cooperation with University of Wisconsin, Memorial Library.
- University of Wisconsin, Memorial Library (1939).
- Wisconsin State Library (unknown).

Milwaukee:
- Milwaukee County Law Library (1934).
- Milwaukee Public Library (1861)—REGIONAL.
- Mount Mary College Library (1964).
- Oklahoma Neighborhood Library (1965).
- University of Wisconsin-Milwaukee Library (1960).

Oshkosh: Wisconsin State University, Forrest R. Polk Library (1956).
Platteville: Wisconsin State University, Elton S. Karrmann Library (1964).
Racine: Racine Public Library (1898).
River Falls: Wisconsin State University, Chalmer Davee Library (1962).
Stevens Point: Wisconsin State University Library (1951).
Superior:
- Superior Public Library (1908).
- Wisconsin State University, Jam Dan Hill Library (1935).

Waukesha: Waukesha Public Library (1966).
Whitewater: Wisconsin State University, Harold Andersen Library (1963).

WYOMING

Casper: Natrona County Public Library (1929).
Cheyenne: Wyoming State Library (unknown).
Laramie: University of Wyoming, Coe Library (1907).
Powell: Northwest Community College Library (1967).
Riverton: Central Wyoming College Library (1969).
Rock Springs: Western Wyoming College Library (1969).
Sheridan: Sheridan College, Mary Brown Kooi Library (1963).

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Gay and Lombard Streets
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334 Meeting Street
Area Code 803 Tel. 577-4171

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Ext. 2151

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Area Code 513 Tel. 684-2944

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Area Code 216 Tel. 522-4750

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Area Code 214 Tel. 749-3287

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20th and Stout Streets
Area Code 303 Tel. 297-3246

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609 Federal Building
210 Walnut Street
Area Code 515 Tel. 284-4222

DETRIOT, MICH. 48226
445 Federal Building
Area Code 313 Tel. 226-6088

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Area Code 919 Tel. 275-9111

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Area Code 901 Tel. 534-3214

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Area Code 305 Tel. 350-5267

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Straus Building
238 West Wisconsin Avenue
Area Code 414 Tel. 272-8600

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Area Code 504 Tel. 527-6546

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Area Code 703 Tel. 649-3611

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17. KEY WORDS (Alphabetical order, separated by semicolons)

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