RARE-EARTH INFORMATION CENTER NEWS

AMES LABORATORY

Iowa State University / Ames, Iowa 50010

Volume I | March 1, 1966 | No. 1

EDITORIAL

In this our first official publication of the Rare-Earth Information Center (RIC for short) we would like to say hello and express the hope that many more of these Newsletters and other official publications will find their way to you. Many of our readers have responded to the news releases issued by the U. S. Atomic Energy Commission and the Ames Laboratory. We are gratified by the correspondence we have received since Jan. 14, 1966. For others this RIC Newsletter and the accompanying brochure may be the first you have heard of RIC. In the following paragraphs we will talk a little more about our operation, how we may be able to assist you and, perhaps, how you may be able to assist us. In other parts of the RIC Newsletter we discuss a number of recent items concerning the rare earths. We hope that some of this information may be useful to you. Your comments concerning RIC and this Newsletter will be appreciated.

* * *

As a matter of definition we are following the guide laid down by the Commission on Nomenclature of the International Union of Pure and Applied Chemistry, and we use the term "rare earths" to include scandium, yttrium and the elements whose atomic numbers are 57 through 71, and the word "lanthanides" to include the elements 57 through 71.

* * *

As one of its more important functions, RIC has been providing answers to inquiries about the rare earths. Some of these inquiries are concerned about the suppliers of rare earths, some about bibliographies, many about a specific subject, and a few about general topics.

About ten percent of the information inquiries we receive are just too vague to be answered (e.g. "We would like to know about the rare-earth metals"). Actually this type of question only reduces the effectiveness of RIC because we must write the requestor and ask him or her to be more specific before we can furnish the information he or she would like to have. This wastes our time because the inquiry is handled twice and there is a delay in getting the answer to the requestor. The solution to the problem is — be specific, it helps everyone.

We answer a specific question generally by informing the requestor about the latest and best reviews available on the subject, plus the latest original journal articles we know of. With this information the requestor should be able to find most of the pertinent literature on the subject by making use of the references cited in the various sources. If we cannot answer a particular question, we will refer the requestor to an expert on the subject.

Information inquiries will be answered as time permits, and especially during the next month or so until RIC reaches its authorized

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The Symbol: Alchemists Discover Rare Earths

No doubt you alchemy buffs may be wondering, "Is the history of the discovery of the rare earths, as recorded in our texts, wrong? Did the alchemists know about these 'unusual soils' centuries before Lt. Arrhenius' discovery in 1787?" No, we at RIC must confess we did not make a new find in the history of the discovery of the rare earths.

The truth is, we took poetic license and combined the alchemist's symbol for earth, "terra," (an inverted equilateral triangle with a cross bar) with the Latin word for rare *(rarus)* to generate the symbol we have incorporated into our letterhead and brochure.

Yes, We Have Some Information

The RIC brochure and this first issue of the RIC Newsletter are being rather widely distributed to nearly 500 identifiable rare-earth research scientists and more than 500 research and industrial organizations active in rare-earth research, our prospective customers, so to speak.

Our plan is to issue the RIC Newsletter to permanent subscribers about four times annually and other pertinent rare-earth information announcements as the need arises. To become a part of our select group of "permanent subscribers" will require a slight amount of effort on your part. You

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New Books

Chemical Behavior of the Rare-Earths Elements

A concise review of the chemistry of these elements is presented by Dr. N. E. Topp in his book, *The Chemistry of the Rare-Earth Elements*, (Elsevier Publishing Company, Amsterdam 1965), 164 pp. This book is divided into twelve chapters: an introduction; rare-earth minerals; separation techniques; salts; solution chemistry; unusual valence states; compounds formed with the Group I, III, IV and V semi- and non-metallic elements; oxides; other chalcogenides; analytical chemistry; the metals; and the applications of these elements. About 40 references are cited in each of the twelve chapters, with two chapters having 72 and 75 references listed. This book should introduce the reader to the literature in many of the areas covered in this book.

Refractory Rare-Earth Compounds

Another of the many books Dr. G. V. Samsonov has written has been translated from Russian into English. This book, *High-Temperature Compounds of Rare Earth Metals with Nonmetals*, (Consultants Bureau, New York, 1965), 280 pp, deals with the borides, carbides, nitrides, silicides and sulfides of the rare earths. It is doubtful that this book is worth $17.50, even though it is probably the best and latest review of the half dozen Samsonov has written concerning these five groups of rare-earth refractory compounds.

Spectroscopy of Lanthanides

As many of the rare-earth scientists well know there has been much activity in the last five years concerned with the theoretical and basic experimental studies of the spectra of the lanthanides as well as their more practical aspects as evidenced by the red europium phosphor in color TV and the various lanthanide lasers. Thus the book by Dr. Brian G. Wybourne, *Spectroscopic Properties of Rare Earths*, (Interscience Publishers, New York, 1965) 236 pp, is a welcome volume to those who are interested in the field of lanthanide spectra.

The 490 references listed at the end of this volume should prove valuable, especially to the scientist who has just started to work in this area or those who have a passing interest in these spectra. This book is divided into six chapters: an introduction to the spectra of the free neutral atoms and ions in the gaseous state; the energy levels of these atoms and ions; the intensities in the lanthanide spectra; the Zeeman effect; the hyperfine structure and isotope shift; and finally, the spectra of the lanthanides in salts and the effect of crystal fields.

Laymen's Booklet

The Atomic Energy Commission has published a 42-page booklet, *Rare Earths - The Fraternal Fifteen*, written by Karl A. Gschneidner, Jr., as part of its Understanding the Atom Series. This booklet, which is written at an elementary level for the layman who has had at least a high school science course or two, covers the history, atomic structure, chemistry and separation, physical properties and applications of these elements.

Although this booklet is non-technical and contains nothing new for the rare-earth scientist, a number of scientists who have copies commented that they found the booklet useful in explaining their work to their wives, relatives and layman friends. Free copies may be obtained from RIC or from U. S. Atomic Energy Commission, P. O. Box 62, Oak Ridge, Tenn. 37831.

Montana Reports Rare Earth Find

We received a letter from Mr. S. J. Chapman of the Montana State Planning Board informing us of some thorium and rare-earth deposits recently found in the Lemhi Pass area of Montana. According to Mr. Chapman, these deposits are believed to be probably the largest in the United States and perhaps the world. Some samples run as high as 12% thorium, 1.5% yttrium, plus corresponding amounts of other rare earths.

If you would like to have further information concerning these deposits, please write to Mr. Samuel J. Chapman, Director, Montana State Planning Board, Sam W. Mitchell Building, Helena, Montana 59601, or call Area Code 406 442-3260 in Helena.

NEW FIND—The map above locates the Lemhi Pass area where a new find of thorium and rare earths has been reported.

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Are Rare Earths a Health Hazard?

The question, "What do we know about the health hazards involved in working with the rare earths?", has been recently answered in the thorough review by Dr. Thomas J. Haley of the School of Medicine at the University of California in Los Angeles. Dr. Haley's article entitled *Pharmacology and Toxicology of the Rare-Earth Elements* appeared in the May 1965 issue of the *Journal of Pharmaceutical Sciences*, Vol. 54, pp. 663-670. The article discusses both the acute and chronic toxicity, biochemistry, metabolism, pharmacodynamic effects (including eyes, skin, muscle and heart), and clinical applications. The 96 references cited in the article should enable the reader to find more detailed information concerning various topics with a minimum of effort.

To answer the question we proposed, we would like to quote the conclusions from Dr. Haley's article: "The pharmacology, toxicology, and clinical application of the stable and radioactive rare earths have been reviewed. These elements have a low to moderate acute toxicity rating and cause very little change in animals when fed for several months. The most striking effects produced by these compounds are the induction of both skin and lung granulomas after local injection or inhalation. Further work should be undertaken to find antidotes. The fatty liver produced by intravenous or intraperitoneal injection, while serious, is a self-limiting condition which is reversible without therapy."

INFORMATION

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will need to send us a postcard or letter stating your intent.

Please be sure to type or print your name legibly (we read minds reasonably well, handwriting is more difficult), your address and, for United States requestors, PLEASE include your ZIP code.

Rare Earths In the News

Many of you, who are not members of the American Chemical Society, or who are not regular readers of *Chemical and Engineering News*, may be interested in the excellent review article *Rare Earths - The Lean and Hungry Industry* which appeared in the May 10, 1965 issue on pages 78-92. As the title implies, this article is primarily concerned with the producers of the rare earths, the commercial applications and the applied research programs being carried out by industry.

In addition the article briefly describes the fundamental studies being investigated in the U. S. universities and government laboratories.

The staff of *Chemical and Engineering News* are to be commended for their competent scientific journalism in preparing this state-of-the-art review of the rare-earth field in the United States. Copies of this article may be obtained for fifty cents a copy from the American Chemical Society, Reprint Department, ACS Publications, 1155 Sixteenth Street, N. W., Washington, D. C. 20036.

MEETINGS

Two Rare-Earth Meetings are Scheduled for September 1966

The British Institute of Physics and Physical Society have planned a three-day Rare-Earth Meeting to be held in Durham, England, September 5-7, 1966, according to an announcement by W. D. Corner, program chairman. A broad program on the physics and metallurgy of rare-earth metals, alloys, and salts is planned. There will be seven invited papers and contributed papers are solicited. Although the meeting is primarily a domestic one, foreign participants will be welcome, Dr. Corner stated. Information concerning the forthcoming meeting may be obtained from D. W. Corner, Physics Department, The University, South Road, Durham City, England.

* * *

The Division of Inorganic Chemistry of the American Chemical Society has planned a three-session symposium on "The Chemistry of Lanthanide and Actinide Elements," for the New York Meeting of the American Chemical Society, Sept. 11-16, 1966. The program will consist largely of invited papers, but contributed papers are being solicited. Further information may be obtained from Dr. Therald Moeller (Department of Chemistry and Chemical Engineering, University of Illinois, Urbana, Illinois 61801), who is primarily concerned with the lanthanide aspect of the program, or Dr. Paul Fields (Argonne National Laboratory, Argonne, Illinois 60440), who is in charge of the actinide portion of the program.

Set Sixth Rare Earth Research Conference

The Sixth Rare Earth Research Conference will be held at the Mountain View Hotel, Gatlinburg, Tenn., May 3-6, 1967, according to Wallace C. Koehler, chairman. Prospective conferees can obtain more information about the conference from: Dr. Wallace C. Koehler, Physics Division, Oak Ridge National Laboratory, Oak Ridge, Tennessee 37831. As of the time of publication of the Newsletter, no general mailing or solicitation of papers had been made.

The rare earth research conferences are becoming truly international in scope. The Fifth Rare Earth Research Conference attracted more than 200 rare-earth scientists representing 14 countries including the United States.

demii Nauk S.S.S.R., Seriya Neorganicheskie Materially), started early in 1965, appears to be a popular journal for publishing papers on rare-earth compounds by Russian inorganic chemists and material scientists. Between 10 and 25% of the papers published in the first three issues which have come to our attention were concerned with rare-earth materials such as sulfides, selenides, tellurides, silicides, germanides, the halides, mixed halide systems and mixed oxides (phosphates, silicates, borates, niobates, etc.).

The papers deal with the preparation, crystal structures, physical properties and phase relationships of these substances. Fortunately, this journal is being translated into English under the title *Inorganic Materials* by Consultants Bureau, but as with most Consultant Bureau translations, the publication of this journal appears to be about twelve months behind the original Russian version.

RARE EARTHERS — A new term, "rare earthers," was coined for us in 1965 when the Holiday Inn, Ames, Ia. welcomed conferees to the Fifth Rare Earth Research Conference in the manner shown above.

answering all information inquiry. We simply do not have the manpower, machinery and finances available to carry out these tasks. RIC, as one of its functions, will compile bibliographies, but the subject matter will be that chosen by RIC. Of course, all RIC bibliographies will be announced in a Newsletter and made available free of charge to anyone who desires a copy.

* * *

We will be happy to include in future issues of the RIC Newsletter announcements concerning information or literature (such as compilations, bibliographies, reviews, films, etc.) that may be available from individuals, institutions or companies. Advertising, promotional literature, brochures, etc., and announcements concerning the same, however, will not be printed in the Newsletter.

* * *

In the above paragraphs we have discussed how we hope to be of assistance to you. And now we would like to tell you how you can help us. By sending us a reprint of each of your papers as they become available you will certainly aid us in our work. Furthermore, it will assure that we do not miss any of your publications as we scan the new issues of the journals.

It would be extremely helpful if the title of your article contained the name of the particular rare-earth element(s) or the words "rare earth" or "lanthanide" or "lanthanon". We are using a Selective Dissemination of Information (SDI) system, in which the titles of articles are received from various sources in tape form and are scanned by a computer for certain key words (a profile). Thus, if the title does not contain the name of a particular rare earth, or the words "rare earth", "lanthanide", etc., we may not obtain a notification of your article. Furthermore, we do not receive a notification if the chemical symbol is used as part of the symbol for a compound, e.g. we get a notification for "cerium trichloride" but not for "$CeCl_3$". In the future we hope to overcome this difficulty, but for the present we must depend upon your accurate titles to make our system work. If you would like to find out more about the Ames Laboratory SDI system, please write RIC or Mr. Charles Sage, Ames Laboratory, Iowa State University, Ames, Iowa 50010.

We would also appreciate receiving news releases concerning new developments involving the rare earths. We do, however, reserve the right to withhold publication of any news release which we believe is more of an advertising gimmick than a genuine news item.

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EDITORIAL

We have received a number of interesting and encouraging letters concerning the first issue of RIC News and the establishment of the Center. We wish to thank those of you who took time to write those friendly letters and cards. In answer to some of your questions and comments we would at this time like to talk about some of the functions RIC *does not* do or plan to do in the foreseeable future. We do not plan to become an abstracting service, that is, to abstract articles, reviews, talks, books, reports, conferences proceedings, etc. There are a number of abstracting journals which perform these functions quite satisfactorily and we believe our entry into this area would be a duplication of effort.

We do not intend to store information concerning the properties of the rare-earth isotopes *per se* (i.e. half-lives, energy levels, radiations, cross sections, etc.). But information concerning some physical, chemical or metallurgical properties of a rare-earth element or compound obtained by using a particular isotope will be included in our files (e.g. a Mossbauer study of a particular rare-earth isotope in a compound to give the isometric shift and thus some information concerning electronic nature of the solid). Information about half-lives, energies, cross sections, etc. of rare-earth isotopes are available from our newly established sister information center, Isotopes Information Center (IIC), at the Oak Ridge National Laboratory at Oak Ridge, Tenn.

* * * * *

A number of our subscribers and users have referred to us as REIC. Please! Our call letters are RIC. REIC are the call letters for our sister information center, Radiation Effects Information Center, located at the Battelle Memorial Institute in Columbus, Ohio.

* * * * *

In private conversations with several scientists the editor has found that some people did not realize it was necessary to write to us in order to receive future issues of RIC News. If any of your co-workers have

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Proposes Periodic Table Changes

In the Aug. 1965 issue of the *American Journal of Physics*, (Volume 33, pp 637-640) Professor David C. Hamilton of the University of California at Los Angeles proposed in his paper, *Position of Lanthanum in the Periodic Table*, that lutetium should be substituted for lanthanum in the corresponding position in the usual periodic table. This interesting proposal is based on the relative nature of the melting points, crystal structures, atomic spectra and existence or non-existence of superconductivity of scandium, yttrium, lanthanum and lutetium.

We agree completely with Professor Hamilton that these data suggest a modification of the periodic table so that scandium, yttrium and lutetium are in the same column. Others, however, might argue that there are equally valid reasons why the periodic table should be left unchanged. The relative nature of the atomic volumes, compressibilities and chemical behaviors (e.g. the elution order of the ions as they come off of the ion exchange columns) of scandium, yttrium, lanthanum and lutetium support the popular periodic table with which we are all acquainted. The editor believes the choice of lanthanum or lutetium in the third column below scandium and yttrium will never be resolved to everyone's satisfaction. Perhaps the best compromise is to draw the periodic table as shown in the cover of our brochure.* We recommend Professor Hamilton's article to those who

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MEETINGS

DURHAM CONFERENCE

W. D. Corner, Chairman of the Rare-Earth Conference to be held at the University of Durham, Durham, England, Sept. 5-7, 1966, has announced the program of invited papers.

The work of seven scientists from five countries will be represented on the invited papers portion of the program. These scientists and their topics are listed below.

1. *Anisotrophy and Magnetostriction of the Rare Earths,* Dr. A. E. Clark, U. S. Naval Ordnance Laboratory, White Oak, Md., U.S.A.
2. *Spin Waves in Rare-Earth Metals,* Dr. P. Wolf, I.B.M. Research Laboratory, Zurich, Switzerland.
3. *Electronic Properties of Alloys and Compounds,* Prof. W. E. Wallace, University of Pittsburgh, Pittsburgh, Pa., U.S.A.
4. *Spectroscopy of Oxides and other Magnetically - Ordered Structures,* Prof. K. M. Hellwege, Technischen Hochschule, Darmstadt, Germany.

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Stability Increased With Cerium

Small quantities of cerium (0.02 wt %) have been reported by H. Ravner, C. M. Murphy and Dr. R. E. Kagarise, all of the U. S. Naval Research Laboratory, to give thermal stability to polydimethylsiloxane-type silicones, *Chem. and Eng. News* 44, 37 (April 1966).

They propose that the anion-propagated "unzipping" degradation mechanism is retarded by the regeneration of siloxane Si-O bonds through a complex containing Ce-O-Si linkages. The effectiveness of the cerium addition is reported to be greater when the relative dimethyl content is large.

RIC Staff

Translation of RIC's statement of intent to "serve the scientific community by collecting, storing, evaluating and disseminating rare-earth information" from an abstraction to a reality comes about through the efforts of five members of the Ames Laboratory staff.

They include Karl A. Gschneidner, Director of the Center; W. E. Dreeszen, in charge of administrative services; W. H. Smith, production; Mrs. Virginia McGriff, secretarial services; and Mrs. Joan Smith, in charge of researching and replying to inquiries. No relation exists between the two Smiths on our staff except a shared interest in RIC activities.

RIC STAFF — Members of the RIC staff standing from left are W. H. Smith, W. E. Dreeszen and Karl A. Gschneidner, Jr. Seated from left are Mrs. Joan Smith and Mrs. Virginia McGriff.

Dr. Gschneidner divides his time between RIC, an Ames Laboratory research group, and teaching duties in the Iowa State University Department of Metallurgy. Mr. Dreeszen is the Ames Laboratory's Head of Information and Security. To him falls much of the administrative burden of the Center. Mr. Smith assists the Center in the production of RIC News, brochures and news releases.

Mrs. McGriff types replies to inquiries and in addition keeps track

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Rare Earth Distribution

A discussion of the consistency of rare earth distributions in crustal sediments and chondritic meteorites with regard to the primordial solar-system matter is given by Dr. L. A. Haskin and F. A. Frey of the University of Wisconsin in "Dispersed and Not-So-Rare Earths," *Science 152,* 299 (April 1966). Data concerning the rare earth content of various types of sedimentary and igneous rocks are compared with the chondritic distribution.

Mineral rare-earth contents and patterns and mantle abundances are also discussed. The authors suggest that "the average rare-earth pattern for the whole earth matches the chondritic pattern, and that the distribution characteristic of the upper crust is a result of geochemical differentiation."

Additional information on this subject may be found in a previous article, "Abundances of the Fourteen Rare-Earth Elements, Scandium and Yttrium in the Solar System (in Meteoritic, Terrestrial, and Solar Matter)," R. A. Schmitt and R. H. Smith, both of General Atomic Division of General Corp., and Larry Haskin, University of Wisconsin, *Rare Earth Research II,* K. S. Vorres, Ed., pp. 583-621, (Gordon and Breach, New York, 1964).

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K. A. Gschneidner, Jr. ..... Editor
* * *

Rare Earths In the News

CONTINUOUS POWER LASER

A sun-powered laser capable of delivering 1 watt continuously has been developed by American Optical Co. The new crystal laser incorporates a neodymium doped yttrium-aluminum garnet. When placed at the focus of a sun-tracking telescope, the laser absorbs some of the visible light and converts it to an intense narrow beam of light at 1.06 microns (infrared), according to its developer. The laser is said to be suitable for use as a communication transmitter.

RARE-EARTH SCIENCE KITS

The Lunex Co., Pleasant Valley, Iowa, has made available two Rare-Earth Experimental Science Kits intended for practical and low cost experimentation in high school and college science laboratories. One kit contains 5 gm samples of both the metals and oxides of lanthanum, praseodymium, neodymium, yttrium, samarium, gadolinium, dysprosium, holmium and erbium. The second kit includes 5 gm metal and oxide samples of the first four elements listed above. Both kits also include descriptive booklets and data sheets.

YTTRIUM PHOSPHOR IMPROVES MERCURY LAMP QUALITIES

Europium doped yttrium vanadate phosphor has graduated from the television picture tube to lighting applications, according to an announcement from the General Electric Co. This phosphor, which first found application in color television, is now being used as a coating material to improve the lighting characteristics and longevity of mercury vapor lamps.

TO CONSTRUCT Y_2O_3 PLANT

Yttrium Corp. of America, a newly formed subsidiary of Rio-Tinto Zinc Corp., London, and Molybdenum Corp. of America, has announced plans for building an yttrium oxide plant for the production of color television phosphors. The plant, which is located at York, Pa., will be supplied raw material from the Rio Algom Nordic Mine at Elliot Lake, Canada.

MEETINGS

(Continued from Page 2)

5. *Properties of Rare-Earth Garnets*, Dr. R. F. Pearson, Mullard Research Laboratories, Redhill, United Kingdom.
6. *Metallurgy of Rare Earths*, Dr. K. A. Gschneidner, Jr., Iowa State University, Ames, Iowa, U.S.A.
7. *Behavior of Rare-Earth Metals Under Pressure*, Dr. D. Bloch, Laboratoire d 'Électrostatique et de Physique du Métal, Grenoble, France.

EDITORIAL

(Continued from Page 1)

not received a copy of this issue of RIC News, then his or her name is not on our permanent mailing list. If you know of anyone who would like to receive this and future issues, please let us know.

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We are starting a new feature in the next issue which we are calling "RARE EARTHERS AROUND THE WORLD." We would like the various scientific research groups who are studying the rare-earth metals, alloys and compounds to send us a picture of their research group and a short description concerning their scientific investigations similar to the picture and write-up on RIC's staff (see p. 2, column 2). We hope that this feature will enable all of us who are working with the rare earths to become better acquainted with each other and the various research programs. This in turn we anticipate will increase interactions between scientists and lead to more productive developments.

Our initial intention is to include about three groups per issue of RIC News; however, we are not firmly committed to this number and it will depend a great deal upon your response. Future issues will also include some of the research groups from the Ames Laboratory. In order to have a little continuity in this feature we have listed below some ground rules. If there is some doubt on your part whether or not a rule applies to you, please write us and we will discuss the problem.

RULES GOVERNING SUBMITTED CONTRIBUTIONS TO THE "RARE EARTHERS AROUND THE WORLD" COLUMN

1. One glossy print of the scientific personnel in a group should be furnished. The print will be returned if requested.
2. A figure caption listing the names of all of the persons in the photograph is required.
3. A description of the group's program should be furnished. The description must be in English and is limited to 300 words.
4. Neither the photograph nor the description may contain anything openly commercial or of a strictly advertising nature.
5. In general a single individual will not be included.
6. This column is limited to scientific research groups, both basic and applied, and is intended to exclude scientific groups and personnel who are involved in production, quality control, marketing, administration, etc.
7. We reserve the right to edit and, if necessary, to reject any contribution. You will be notified of any editorial changes or rejections.
8. These contributions will be published on a first come-first served, space available basis.
9. Copy deadline is 30 days prior to publication dates which are March 1, June 1, September 1 and December 1.

Reproduced below is the program of the symposium on "The Chemistry of Lanthanide and Actinide Elements" for the New York Meeting of the ACS, Sept. 11-16. The program arrived after our copy deadline.

Symposium on the Chemistry of the Lanthanide and Actinide Elements

MONDAY MORNING

K. W. Bagnall. Recent Advances in Actinide and Lanthanide Chemistry. (Opening Lecture).

MONDAY AFTERNOON

Therald Moeller. Introductory Remarks.

Edgar F. Westrum, Jr. Developments in Chemical Thermodynamics of the Lanthanides.

P. Niel Yocum. Preparation and Identification of Divalent Lanthanide Ions as Dilute Solutes in Alkaline Earth Halide Solid Solutions.

John D. Corbett, Robert A. Sallach, Donald A. Lokken. Physical Characterization of the Metallic LaI_2 and CeI_2 and the Phase $LaI_{2.42}$.

LeRoy Eyring. Fluorite-Related Oxide Phases of the Rare Earth and Actinide Elements.

W. T. Carnall, P. R. Fields. Recent Developments in the Theoretical Interpretation of Lanthanide and Actinide Absorption Spectra in Solution.

D. M. Gruen, C. W. DeKock. Absorption Spectra of Gaseous Lanthanide Trihalide Molecules.

TUESDAY MORNING

Paul R. Fields. Introductory Remarks.

Mark Fred. Electronic Structure of the Actinide Elements.

N. Edelstein, W. Easley, R. McLaughlin. Optical and Electron Paramagnetic Resonance Spectroscopy of Actinide Ions in Single Crystals.

Henry R. Hoekstra, Robert H. Marshall. On Some Uranium-Transition Metal Double Oxides.

Cornelius Keller. The Solid-State Chemistry of Americium Oxides.

R. A. Penneman, L. B. Asprey, T. K. Keenan. Tetra- and Pentavalent Actinide Fluoride Complexes, Protactinium to Curium.

Conrad E. Thalmayer, Donald Cohen. Actinide Chemistry in Saturated Potassium Fluoride Solution.

T. W. Newton, F. B. Baker. A Review of the Kinetics of the Aqueous Oxidation-Reduction Reactions of Uranium, Neptunium, Plutonium, and Americium.

TUESDAY AFTERNOON

Richard Thompson, J. C. Sullivan. Redox Reactions of Neptunium(V).

C. Musikas. A Contribution to the Study of the Oxidation Potential of the Berkelium (III)-(IV) Couple in Various Media.

L. E. Trevorrow, M. J. Steindler, D. V. Steidl, J. T. Savage. Condensed Phase Equilibria in the System MoF_6-UF_6.

Henry R. Hoekstra. Uranyl Metaborate.

J. L. Ryan. Octahedral Hexahalide Complexes of the Trivalent Actinides.

J. L. Ryan, W. E. Keder. Anionic Acetato Complexes of the Hexavalent Actinides and the Anion Exchange and Amine Extraction of Hexavalent Actinide Acetates.

F. K. Fong, M. A. Hiller, F. G. Krajenbrink. Ion-Complexing and Valence Change in Rare-Earth Doped CaF_2.

L. B. Asprey, J. S. Coleman, M. J. Reisfeld. Preparation and Properties of Some Tetravalent Praseodymium Compounds.

E. J. Wheelwright, F. P. Roberts, U. L. Upson, L. J. Kirby. Ion-Exchange Separation of Kilocurie Quantities of High Purity Promethium.

WEDNESDAY MORNING

J. B. Walker, G. R. Choppin. Thermodynamic Parameters of Fluoride Complexes of the Lanthanides.

R. E. Sievers, K. J. Eisentraut, D. W. Meek, C. S. Springer, Jr. Gas Chromatographic and Nuclear Magnetic Resonance Studies of Rare Earth Beta-Diketonates.

Daniel L. Ross, Joseph Blanc. Lanthanide Chelates as Laser Materials.

Stephen J. Lippard. Nuclear Magnetic Resonance Studies of Eight-Coordinate Rare Earth β-Diketonates.

L. C. Thompson, B. L. Shafer, J. A. Edgar, K. D. Mannila. Complexes of the Rare Earths. IX. N-Substituted Iminodiacetic Acids.

Byungkook Lee, M. D. Lind, J. L. Hoard. Stereochemistry of the Ethylenediaminetetraacetato Chelates of the Lanthanide Ln^{3+} Ions.

David Cousins, Alan Hart. Complexes of Lanthanide Nitrates with Triphenylphosphine Oxide and Triphenylarsine Oxide.

Eugene V. Kleber. Rare Earth Research Trends.

RIC Staff

(Continued from Page 2) of our select group of permanent subscribers. Generating material for Mrs. McGriff is the job of Joan Smith. As RIC's only full-time staff member, Joan occupies her time with interpreting, researching and drafting replies to our requesters, and collecting and compiling new data as it becomes available.

Through the combined efforts of the RIC staff we hope to make RIC a valuable adjunct to the research efforts of rare earthers.

Mountain Pass Mine

Information concerning Molybdenum Corp. of America's Mountain Pass Mine, source of europium oxide for the television industry, was summarized in the California Division of Mines and Geology publication, *Mineral Information Service*, *18* (2), 23 (February 1966). Although the article highlights mainly the geological aspects of the mine, it also contains information for those who have interests in other areas.

Included in the article are a brief history of the mine, several geologic maps, the geology and mineralogy of the ore body, and sections on mining, milling and processing procedures.

THE MAP above locates the Mountain Pass Mine featured in a California publication, "Mineral Information Service," in February of this year.

Reports, Brochures, Booklets

GLASS

Since the publication of the previous issue of RIC News (March 1966), two brochures of interest to rare earthers have come to our attention. Molybdenum Corp. of America has available an eight-page brochure entitled "Rare Earths in the Glass Industry," which describes the theory and experimental results of glass decolorization. Included are sections concerning a comparison of the effectiveness of various decolorizing agents, glass coloration, and other applications of rare earths to the glass industry. Copies may be obtained from Molybdenum Corp. of America, 280 Park Avenue, New York, New York 10017.

METALS AND ALLOYS

Ronson Metals Corp., 45-65 Manufacturers Place, Newark, N.J. 07105, has compiled several bibliographies and/or information sheets regarding ferrous and non-ferrous alloys, gettering, and the uses of rare-earth metals in the electronic industry. These are available in the brochure "Rare Earth Metals and Alloys."

Volatile Chelates

Volatile chelates of thirteen trivalent lanthanides, yttrium and scandium have been prepared in 90 to 97% yields using 2,2,6,6-tetramethyl-3,5-heptanedione (H[thd]). Dr. R. E. Sievers and Lt. K. J. Eisentraut, Wright-Patterson Air Force Base, Ohio, report that the chelates are thermally stable, anhydrous and unsolvated compounds of formula $M(thd)_3$ in an article entitled "Volatile Rare Earth Chelates," *J. Am. Chem. Soc. 87* (22), 5254 (November 1965).

Because of the significant volatility differences of the complexes, separation by gas chromatography is possible, especially for the rare earths lanthanum to dysprosium. On the basis of retention behavior the authors suggest that the volatility decreases with increasing ionic radii of the trivalent ions.

PERIODIC TABLE

(Continued from Page 1) have not seen it since he makes some valuable remarks concerning this point. Dr. Hamilton is to be commended for his forthright expression of his views.

* We did not propose this form of the periodic table to solve this question. We borrowed it from Fig. 3, Page 7 of the U. S. Atomic Energy Commission's booklet, *Rare Earths-The Fraternal Fifteen*, first published in Dec. 1964.

New Books

RARE EARTH RESEARCH III

The proceedings of the Fourth Rare Earth Research Conference held April 22-25, 1964 at Phoenix, Arizona have been compiled into the book, *Rare Earth Research III*, LeRoy Eyring, Ed., (Gordon and Breach, New York, 1965), 749 pp. The reference edition of this work is priced at $39.50 while the professional edition sells for $19.50.

As with the other books concerning earlier conferences, this book contains current research in the chemistry, physics and metallurgy of the rare earths. Specifically, it consists of the following sections: magnetic and electrical properties of rare-earth compounds, properties of the metals and their alloys, optical properties, solution chemistry, and solid state chemistry of rare-earth materials.

It is unfortunate that the conference proceedings required two years to the date to reach the hands of the scientists. Basically, production delays accounted for the late issuance, since it required nine months to get the book out after the page proofs had been assembled. Still, special attention to this book should be given by those interested in the current research of prominent workers in these fields.

Letters

To the Editor:

We have considerable interest in the use of rare-earth elements as the attached circular will show you ("Studies on the Application of Radioisotope Techniques in Stream Pollution Problems in the Pulp and Paper Industry"). We are presently applying the use of rare-earth elements to problems in the tagging of paper mill fibers in process and pollution control studies. If your readers have an interest in receiving a copy of this, we would be glad to mail them upon receipt of their names and addresses.

I would like to communicate with anyone who has an interest in the application of the tagging of paper-fibers or any other kind of fibers using the rare-earth elements and to receive copies of papers on this particular subject.

R. M. Chatters
College of Engineering
Washington State Univ.
Pullman, Wash. 99163

Coordination Chemistry

A 50-page review of the complexing chemistry of rare-earth metals and yttrium is available in *Chemical Reviews 65,* 1-50 (January 1965). The article, "The Coordination Chemistry of Yttrium and the Rare Earth Metal Ions," by Therald Moeller, D. F. Martin, L. C. Thompson, R. Ferrus, G. R. Feistel, and W. J. Randell, all of the University of Illinois, concerns the classification, stabilities, bonding and applications of rare-earth complexes. In addition, the scandium and actinide coordination chemistries are viewed in the light of rare-earth coordination chemistry.

The 651 references at the conclusion of this review provide ample opportunity for the interested reader to find additional information on this subject through 1962 and into early 1963.

New Assault on Absolute Zero?

The use of rare earths to attain temperatures of 10^{-4} to 10^{-5}°K has been suggested by Al'tshuler, Kazan' State University, USSR, *JETP Letters 3,* 112 (1966). Presently it is possible by using salts containing rare-earth ions with an odd number of 4*f* electrons (in particular cerium magnesium nitrate) to reach temperatures of about 10^{-3}°K by adiabatic demagnetization technique. Because several of the trivalent rare-earth ions with an even number of 4*f* electrons have nuclear spins greater than zero and large values for the hyperfine interaction (the interaction between the nuclear magnetic dipoles and the electron dipoles), these two properties should enable us to reach these low temperatures. Al'tshuler suggests two methods: one for rare earths with large nuclear spins ($I > 3/2$) and the other for rare earths with small spin values.

If salts of praseodyium ($I = 5/2$) or holmium ($I = 7/2$) are maintained at pumped liquid ^{3}He temperatures (~ 0.5°K) and magnetic fields of 2×10^4 Oe are used, then adiabatic demagnetization of these materials should permit one to attain 10^{-4} to 10^{-5}°K. If salts of thulium ($I = 1/2$) are cooled to about 10^{-2}°K by conventional magnetic demagnetization techniques using a paramagnetic salt, it might be possible to reach 10^{-5}°K by rotating the salt from 0 to 90° with respect to the magnetic field so that the gyromagnetic factor decreases from approximately 70γ to γ, where γ is the free atom value of the gyromagnetic ratio.

Of course one of the problems is measuring the temperature as one nears absolute zero, but Professor Al'tshuler also has described a technique to measure these extremely low temperatures.

Although this is an exciting proposal, it should be noted that Professor Simon of the Clarendon Laboratory of the University of Oxford reached a temperature of about 10^{-5}°K ten years ago by using the hyperfine interaction in copper after cooling down to 10^{-2}°K by means of adiabatic demagnetization of a paramagnetic salt, N. Kurti, *Phys. Today 13,* 26 (1960). Perhaps by combining several of these techniques in tandem and using rare-earth salts it may be possible to obtain temperatures even lower than 10^{-5}°K. Are many of you cryogenic-rare earthers going to take up the battle cry, "Onward to Absolute Zero"?

Sees Magnetic Applications for The Rare Earths

The potential applications of the rare earths in magnetic materials has been explored by Dr. S. Methfessel of IBM's Thomas J. Watson Research Center, *IEEE Trans. on Magnetics,* Vol. MAG-1, 144 (1965).

The topics covered in this article are: (1) a comparison of magnetic behaviors of the rare-earth and iron group elements; (2) magnetic properties of metallic rare-earth metals, alloys and compounds; (3) possible ways to increase the Curie temperatures of these metallic materials; and (4) magnetic properties of non-metallic rare-earth compounds, particularly the rare-earth ferrites and garnets, and europium monochalcogenides.

Dr. Methfessel concludes that it is difficult to predict the future use of these metals, since they are too new to be properly evaluated, but he feels that their low Curie temperatures, usually less than room temperature, will be a handicap in their utilization.

Furthermore, he notes that as a result of systematic scientific studies, a better understanding of the magnetic nature of materials will be obtained. This should lead to the development and improvement of magnetic materials with useful properties for commercial application.

Rare Earths at High Pressures

Recently we saw a copy of the proceedings of the high pressure symposium held in Tuscon, Ariz. in April 1965, *Physics of Solids at High Pressure*. C. T. Tomizuka and R. M. Emrick, Eds., (Academic Press, New York, 1965).

Five of the papers in this volume may be of interest to rare-earth scientists. Three papers are based on experimental studies and two are theoretical in nature.

Robinson, Milstein and Tan, University of California at Los Angeles, pp. 272-297, reviewed the progress of their studies of the magnetic properties of gadolinium, terbium and dysprosium. Professor Vereschagin of the USSR, pp. 460-466, discussed many aspects of his broad research program including his studies of lanthanum and cerium. The third experimental paper is by A. Jayaraman, Bell Telephone Laboratories, pp. 478-495, who summarized most of his recent research on the crystal structures, pressure-temperature (one-component) phase diagrams and melting phenomena of the rare-earth metals.

The theoretical paper by Blandin, Coqblin and Friedel, University of Paris, pp. 233-251, discusses the electronic configurations on the basis of the virtual bound state model of the rare-earth metals, and the effect of pressure on these configurations. The last paper is by W. Kohn, University of California at San Diego, pp. 561-566, who briefly mentions that his theoretical model is capable of explaining the electronic change on proceeding at high pressures from the γ-Ce (normal cerium) to α-Ce (collapsed form) at the critical point.

Can You Help?

The Research Materials Information Center (RMIC) at Oak Ridge National Laboratory is seeking information as to the availability of a number of research materials.

Among the materials on the list distributed by RMIC are several in the rare-earth family. *All the materials listed are desired in single-crystal form except those marked by an asterisk.*

If you have any information concerning the availability of these materials, please correspond directly with Dr. T. F. Connally, Research Materials Information Center, Oak Ridge National Laboratory, Post Office Box X, Oak Ridge, Tenn. 37830. We would appreciate a carbon copy of your information.

Material	*Purity*	*Specifications*
^{176}Lu	—	—
Rare Earths	> 3N	—
*Rare Earth Bromide	3-4N	—
*$Sm(II)SO_4$	3N	Polycrystalline and powder
$YAlO_3$ and $YGaO_3$	—	Approx. one cubic centimeter, impurity or doped with rare earths

Rare-Earth Information Center
Ames Laboratory, USAEC
Iowa State University
Ames, Iowa 50010

Application to mail at second-class postage rates is pending at Ames, Iowa

RARE-EARTH INFORMATION CENTER NEWS

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Iowa State University / Ames, Iowa 50010

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Editorial

As most of our readers are aware, RIC is planning a compilation of rare-earth producers and their products. This information we hope will be of assistance, not only to the RIC staff, but also to both the user and producer. Presently, the largest number of inquiries about a particular subject are those concerning the availability of a rare-earth chemical, metal or mixture. In general we know most of the companies which produce a particular product, but we may have overlooked one or two others, simply because we did not know the company manufactured this product. We hope that the survey will increase our knowledge concerning the availability of rare-earth materials. As soon as the compilation has been completed, we will announce it in a future issue of RIC News.

We are very appreciative to those of you who wrote concerning companies whose names were not on our list of rare-earth suppliers. Your response has brought to our attention about 30 more companies who are thought to supply rare earths. Most of these are located outside the United States. We will be glad to furnish the names and addresses of these companies to whomever desires a copy.

* * * * * *

As noted in our last issue of RIC News, we are starting with this issue the series, "Rare Earthers Around the World." You will find in the box located in the right hand column of this page, a listing of the groups which appear in this volume. The group write-ups and pictures are placed throughout the issue. We thank those of you who have sent in your contributions, and we are looking forward to receiving other contributions in the future.

* * * * * *

Hopefully, as you read this volume, the editor of RIC News will be completing his European trip. The itinerary includes visits to several academic institutions and one industrial research laboratory. Prior to returning I will be attending the Durham Rare-Earth Conference. In the December issue of RIC News we plan to include a brief summary of the Durham Conference and the visits.

Rare-Earth Fertilizers?

Rare earths in additions up to 10 ppm have been reported to benefit plant growth. H. H. Sharoubleem and N. E. Milad of A'in Shams University, Cairo, Egypt reported their findings on the Phaseolus vulgaris, a type of legume, in *Soil Science* 101 (2), 130-4 (Feb. 1966).

According to these experimenters, the result of the rare earth supplements obtained from monazite were: (1) increased water content of roots; (2) increased dry matter of tops; (3) a higher top to root ratio; and (4) a change in the amounts of various elements present in the plants.

With rare-earth additions of less than 5 ppm, the sodium, potassium, and nitrogen concentrations increased and the calcium, magnesium and phosphorus concentrations decreased. Rare-earth additions of more than 5 ppm caused the opposite effect, i.e., decreased the sodium, potassium and nitrogen concentrations and increased calcium, magnesium and phosphorus contents.

Rare Earthers Around The World

LUNEX TECHNICAL STAFF—Standing from left are O. F. (Joe) Isenberg, Dr. John Moriarty and James E. Humphreys. Seated are Mark Nelson and Janice Pelon.

Lunex Company Technical Staff

The research efforts of the Lunex Company technical staff are directed toward developing ways and means of producing large quantities of high-purity metals and compounds, and improving existing ferrous and non-ferrous alloys through the use of rare earths. Investigations of binary alloy systems to discover new intermetallic compounds and the characterization of their crystal structure are also of major interest to the group.

In addition, studies of magnetic and electrical properties of these materials are carried on by the Lunex technical staff.

Dr. John L. Moriarty is the research director at Lunex. He is in charge of both basic and applied research programs. O. F. (Joe) Isenberg, works superintendent, numbers among his many duties the development of new products. Research associate James E. Humphreys is responsible for directing the work of the analytical, metallographic and x-ray laboratories.

Two members of the Lunex technical staff are gaining a knowledge of fundamental research techniques while completing their undergraduate work at nearby Augustana Col-

(Continued on Page 3)

Rare Earths In the News

Promethium-147 Lighting

Another possible use for the rare earths has been announced recently. Major auto makers are considering the use of promethium-147 for the illumination of auto ignition key locks, windshield wiper knobs and gearshift indicators. According to 3M, major supplier of promethium-147 devices, such illumination would be permanent and reliable, as well as being less expensive than the electric bulb systems now in use.

More Enlightenment

Fluorescent lamps are now on the rare-earth bandwagon. According to Westinghouse, its new fluorescent lamps which use yttrium oxide and europium to supplement other phosphors have a significantly higher light output and a better color balance. The europium, as in color TV, is used to increase the brightness of the red color which previously was overpowered by the blue and green.

YIG Crystals

Bell Telephone Laboratories have developed a technique for growing yttrium ion garnet (YIG) crystals up to a half pound in size. The crystal is prevented from redissolving by draining the flux from the crucible which remains fixed in the furnace. Crystal nucleation and growth is encouraged by an oxygen stream which cools the crucible bottom.

RIC Staff Change

We are pleased to announce that Miss Kay Varnum has joined the RIC staff as a full-time secretary. Mrs. Virginia McGriff, who assisted RIC on a part-time basis, is now working full-time for the Ames Laboratory Publications Office.

Conference Proceedings

We have seen two recently published conference reports, which contained articles of interest to rare earthers. There are three papers dealing with the rare-earth metals in the book *Optical Properties and Electronic Structure of Metals and Alloys*, F. Abeles, editor, North-Holland Publishing Company, Amsterdam and John Wiley, New York (1966), and one paper in *Transactions Vacuum Metallurgy Conference 1965*, L. M. Bianchi, editor, American Vacuum Society, Boston (1966).

The results of recent optical studies on the rare-earth metals are summarized by C. Schuler, IBM, Zurich Research Laboratory, pp. 221-236. His data show that the room temperature optical properties of the trivalent metals differ from those of the divalent metals Eu and Yb. The results are discussed in terms of the recent band structure calculations. The effect of magnetic ordering at low temperature on the optical properties was also studied.

The optical properties of Gd and Tm as deduced from the band structure calculations are discussed by Dimmock and Freeman, Massachusetts Institute of Technology, and Watson, Brookhaven National

(Continued on Page 4)

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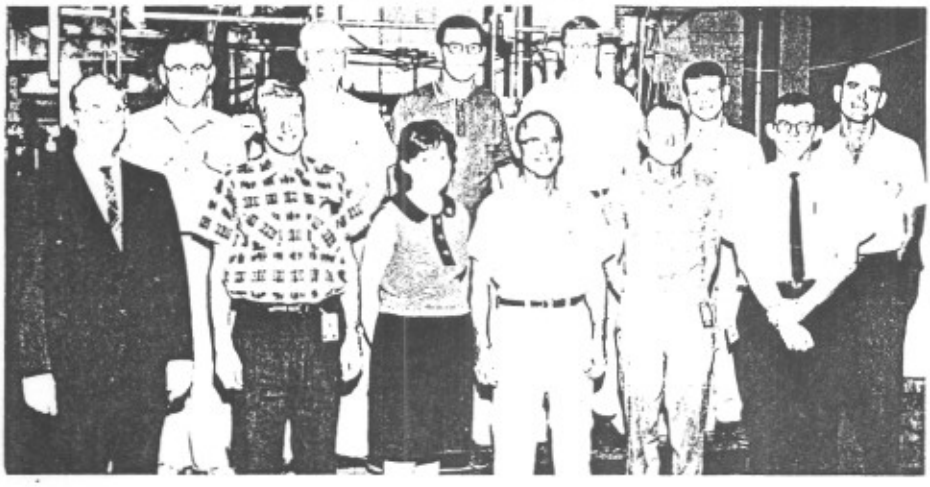

ION-EXCHANGE GROUP — In the front row from left are Dr. Jack E. Powell, James Farrell, Maureen Matkovich, Roy Whetstone, Bill Carroll and Christopher Devine. In the back row from left are Ben Storby, Vernon Munson, Dr. Glyn Rowlands, Marvin Adolphson and Douglas Johnson.

Ames Laboratory Ion-Exchange Group

The research activities of Physical and Inorganic Chemistry Group II of the Ames Laboratory, Iowa State University, are related to the separation of rare earths by ion exchange with primary emphasis on screening potential eluting agents by determination of stability constants of rare-earth chelate species. The group is headed by Dr. Jack E. Powell, senior chemist.

Solid chelate compounds are also prepared and tested with respect to solubility, stoichiometry and hydration. Four graduate assistants, Maureen Matkovich, Christopher Devine, Marvin Adolphson and Douglas Johnson are currently studying a variety of α-hydroxycarboxylate and dicarboxylate chelates of the rare earths. Associate James Farrell is similarly engaged and, in addition, writes the computer programs which are used in calculating the stability constants.

Dr. Glyn Rowlands, post-doctoral associate, has been working jointly with Dr. Powell on the correlation of stability constant data and is currently making direct determinations of the rare-earth separation factors which are operative in several interesting ion-exchange elution systems.

Promising chelate systems are eventually investigated on a modest scale to evaluate their potential as eluants in the separation of rare earths. As a by-product of these operations pure rare-earth oxides are made available to other groups in the laboratory. Harvey Burkholder, assistant chemist, is general supervisor of the rare earth-separations pilot plant, which is operated by technicians Roy Whetstone, Bill Carroll, Ben Storby and Vernon Munson. Part of the pilot plant is presently being operated at elevated temperatures (95° C.)

ADDRESS CHANGE

Word has come from Michigan Chemical Corporation that their general offices are now located at 2 North Riverside Plaza, Chicago, Illinois 60606. The firm's telephone number is 312 263-0580.

LUNEX COMPANY

(Continued from Page 2)

lege in Rock Island, Ill. They are Janice Pelon and Mark Nelson, both seniors majoring in chemistry. They are employed on a part-time basis as research assistants.

MEETINGS

Red Letter Days

May 3-6, 1967 are red letter days for Rare-Earth Researchers. These are the dates for the Sixth Rare-Earth Conference to be held at Gatlinburg, Tennessee. This conference is being sponsored by the Air Force Office of Scientific Research and the Oak Ridge National Laboratory.

Dr. Wallace C. Koehler, conference chairman, has issued a call for papers. Interested individuals should submit an abstract to the conference chairman by December 1. Further information may be obtained from Dr. Koehler, ORNL, Oak Ridge, Tennessee 37831.

Mineral Facts and Problems

Excellent reviews of "capsule" background information on scandium, yttrium and the lanthanides appear in the Bureau of Mines Bulletin 630, *Mineral Facts and Problems*, 1965 ed. Two chapters by John G. Parker entitled "Rare-Earth Elements," and "Yttrium," and a chapter, "Scandium," by Donald E. Eilertsen include such information as size, organization and geographic distribution of the industry; definitions of terms, grades and specifications; technology of these elements, including their geology, mining, processing, separation and metal preparation; uses, statistical information, production, resources, prices; and future outlook and problems.

Preprints of the chapters may be obtained from the Superintendent of Documents, U. S. Government Printing Office, Washington, D. C. 20402, at a cost of $.05, $.10, and $.15, respectively for the chapters "Scandium," "Yttrium," and "Rare-Earth Elements."

New Books

Berzelius' Biography

A recent biography (1966) by Dr. J. Erik Jorpes of the Royal Carolinian Medico-chirurgical Institute on the life and work of the eminent Swedish chemist, Jac. Berzelius, has been translated into English by Barbara Steele. This well-written and beautifully illustrated book describes, in addition to Berzelius' scientific endeavors, the "state of the art" of chemistry in Europe during Berzelius' lifetime and his relations with his co-workers and other prominent researchers.

Among Berzelius' notable achievements is the discovery of cerium by the joint efforts of Berzelius and Hisinger. The role played by Berzelius in the discovery of the other rare-earth elements is also included.

A copy of the book, *Jac. Berzelius: His Life and Work*, may be obtained from Almqvist and Wiksell, Stockholm, Sweden.

MAGNETISM 1965

A review of papers published in 1965 on the magnetic properties of the rare-earth metals, alloys and compounds is given in *Magnetism and Magnetic Materials: 1965 Digest*, R. L. White and K. A. Wickersheim, Eds. (Academic Press, New York).

The most important paper regarding the rare earths is chapter 5, a nine-page review containing 60 references, by C. E. Olsen of the Los Alamos Scientific Laboratory. In this chapter, the general and theoretical papers are reviewed, along with those dealing with the experimental results reported on the rare-earth metals, alloys and intermetallic compounds.

Additional information concerning the magnetic and superconducting properties of the rare earths including their alloys and intermetallic, semimetallic and inorganic compounds will be found scattered throughout in all but four of the remaining eighteen chapters.

Portable X-Ray Source

K. L. Krabbenhoft and F. L. Green evaluated five different rare-earth isotopes as possible portable radiographic sources for clinical diagnostic uses. They concluded that Yb^{169} proved to be the most practical of all the isotopes evaluated up to that time. [Am. J. Roentgenology, Radium Therapy, Nucl. Med. *90*, 123 (1963)].

PROCEEDINGS

(Continued from Page 2)

Laboratory, pp. 237-245. Estimated energies of transitions between bands which have been magnetically split are compared with the energies in the infrared spectra observed in magnetically ordered Dy and Ho.

The last paper by Blodgett, Spicer and Yu, Stanford University, pp. 246-256, deals with the band structure of Gd as deduced from photoemission and optical studies. Their results are compared with the theoretical calculations of Dimmock, Freeman and Watson, noted above.

In the conference proceedings of the 1965 Vacuum Metallurgy Conference, pp 99-135, K. A. Gschneidner, Jr., Iowa State University, describes the use of vacuum metallurgy in the preparation and purification of rare-earth metals. Also included in this paper is a listing of the current best values (1965) of some of the physical properties of the rare-earth metals.

An Yttrium-Cobalt Permanent Magnet

A recent study of the magnetic properties of YCo_5 by K. J. Strnat and G. I. Hoffer, (Wright-Patterson Air Force Base, Ohio) indicated that this compound may become one of the best permanent magnet materials available. The energy product, the product of the magnetic induction and magnetic field intensity, of YCo_5 is 29.2×10^6 GOe, approximately three times larger than the best magnets available today. Furthermore, its high Curie temperature (630°C), extremely high room temperature anisotropy constant (5.7×10^7 erg/cm^3) and good corrosion resistance are all favorable for the use of YCo_5 as a fine particle permanent magnet.

The biggest drawback is the cost of this material, which is estimated to be about $30 per pound, as compared to $1.25 to $10 per pound for Alnico magnets. The authors suggest that the substitution of cerium or mischmetal or didymium for all or part of the yttrium would lower the cost.

The details of the technology and economic considerations are to be found in an Air Force Materials Laboratory report, AFML-TR-65-466, which should be available from the Clearinghouse for Federal and Scientific Technical Information, Sills Building, 5285 Port Royal Road, Springfield, Virginia 22151.

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Application to mail at second-class postage rates is pending at Ames, Iowa

RARE-EARTH INFORMATION CENTER NEWS

AMES LABORATORY
Iowa State University / Ames, Iowa 50010

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BIRMINGHAM GROUP — Pictured from left are J. D. Speight, Dr. I. R. Harris, Prof. G. V. Raynor, R. C. Mansey, Dr. M. Norman and T. B. Merryfield.

Birmingham Rare-Earth Metallurgy Group

The main programme of the University of Birmingham, England, Rare-Earth Research Group is the physico-metallurgical investigation of alloys and intermediate phases of rare-earth metals with each other and with selected non-rare-earth metals (to date: thorium, zirconium, indium, tin and palladium), in order to contribute to the theory of alloying as applied to these materials.

Metallographic, lattice spacing and magnetic susceptibility methods have been used. Much of the work has been concentrated on alloys containing the metal cerium as solute, whose effective atomic diameter depends upon the environment in the alloy. The most important factors involved are the strain energy of alloy formation and the number of valency electrons per atom in the solvent.

Gadolinium alloys are being systematically studied; the apparent atomic diameter of gadolinium in solid solution is sensitive to the presence or absence of magnetic interactions. Alloys based on ytterbium are also under examination.

Though much effort is concentrated on binary solid solutions, ternary solid solutions are of increasing importance since the relevant factors can be continuously varied from those in a system MR to those characteristic of M′R. Intermediate phases are also studied, and it is found that the factors which are important in solid solutions determine the behaviour of cerium and gadolinium in intermediate phases.

Future plans of the group include detailed studies of magnetic susceptibilities and other physical properties as functions of temperature over a wide range, with a view to definition of the electronic constitutions of rare-earth metals in alloys.

Studies are also in progress on the relationship of the sequence of crystal structures in intra-rare-earth alloy systems to the crystal structures of the pure metals and the variation of this with atomic

(Continued on Page 5)

4f Ligand Field Interactions

Analysis of thermochemical data of lanthanide 1:3 diglycolate and dipicolinate complexes indicates that ligand field stabilization effects involving 4*f* electrons contribute a few hundred calories to the heat of formation. The details of this study were presented in *Nature* (*211*, 1172-3 [1966]) by L. A. K. Staveley, D. R. Markham and M. R. Jones of the University of Oxford.

We would also like to point out that approximately four years ago, G. P. Espinosa suggested on the basis of lattice parameter data of lanthanide iron garnets that the 4*f* electrons interacted with the crystal field (J. Chem. Phys. *37*, 2344 [1962]).

These conclusions suggest that the influence of the 4*f* electrons in the lanthanides, though small, is not negligible and may play an important role in the chemistry, physics and metallurgy of these elements.

Rare Earthers Around The World

International Happenings—

Rare-Earth Research–Europe

During the latter days of August and early September the editor criss-crossed Europe visiting a number of universities and one industrial research laboratory. The kind and generous hospitality extended to us by our hosts and hostesses during our brief but delightful visit was deeply appreciated and will be fondly remembered for many years to come. Although we saw many interesting things and had many enjoyable experiences, both scientific and non-scientific, I shall henceforth limit the discussion to the scientific highlights of the trip.

GERMANY

The first stop on my European trip was a visit with Dr. Fritz Weigel of the Institute for Inorganic Chemistry at the University of Munich. Dr. Weigel is the foremost authority on the inorganic chemistry of promethium. Unfortunately, because of new building construction, his hot chemical facilities have been shut down for about a two-year period, and I was unable to see them. The inorganic chemistry of promethium and its relationship to that of the remaining lanthanide elements is quite important because in several instances the chemistry of the promethium bridges the gap or differences between different chemical behaviors of neodymium and samarium.

Of historic interest, I saw some of the original rare-earth compounds and solutions of Wilhelm Prandtl, one of the early prominent rare-earth chemists. These materials were purified by the tedious fractional crystallization technique, and are now property of the Bavarian Academy of Sciences.

HOLLAND

At the Philips Research Laboratories, Einhoven, I visited Drs. K. Buschow and J. Van Vucht. Dr. Buschow is involved in crystallographic, phase diagram and magnetic susceptibility studies on the rare earth-aluminum, -germanium and related alloys. Dr. Van Vucht's present interests are mostly concerned with superconducting materials composed of non-rare-earth metals; however, in the past he has made some studies on rare-earth alloys.

Most of our discussions centered on the electronic nature of rare-earth metals and alloys, as determined from magnetic, crystallographic, and specific heat measurements, and from alloying principles.

ITALY

The next stop in our itinery was the University of Genova, where I visited with Professor A. Iandelli and his co-workers Drs. G. Bruzzone and G. L. Olcese. Their main interests are the crystal chemistry and magnetic properties of the rare-earth intermetallic compounds and the nature of the valency of cerium, europium and ytterbium in intermetallic phases. Our discussions were mostly concerned with the determination of valency of cerium, europium and ytterbium in intermediate phases from magnetic susceptibility and molar volume considerations. The reliability and limitations of these data were also reviewed.

AUSTRIA

Technical University of Vienna.

At the Institute of Applied Physics, I visited Dr. H. Kirchmayr and some of his co-workers. They are working on rare earth-mercury phase diagrams and an amalgam process for preparing intermetallic phases which may be difficult or impossible to prepare by ordinary techniques. The amalgam process consists of dissolving stoichiometric amounts of a rare-earth and some other metal, such as manganese or cobalt, in liquid mercury. The liquid mercury is filtered to remove the mercury-rare earth-manganese solid alloy. The mercury is removed from this ternary alloy by heating in vacuum and the residue, which consists of finely divided rare-earth and manganese in intimate contact, is further heated to form the desired rare-earth intermediate phase. Magnetic susceptibilities and crystallographic studies are being made on the resultant compounds.

University of Vienna.

While at the Institute of Physical Chemistry, I visited Professor H. Nowotny and several of his co-workers. Dr. Nowotny is the foremost authority on the crystal chemistry of the transition metal carbides, borides, silicides, germanides, gallides, etc. Of particular interest are their results concerning the stabilization of $AuCu_3$ type compounds of the R_3M stoichiometry, where M is Ga, In, Tl, Sn and Pb, by small amounts of carbon.

(Continued on Page 8)

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The Editor Reports—

Durham Rare-Earth Conference

The conference took place at the picturesque city of Durham located in beautiful rolling hills of Northeast England. Our cordial hosts, Drs. W. D. Corner and K. N. R. Taylor, were very well organized, and the conference and extracurricular activities came off quite smoothly.

This conference was primarily concerned with the solid state physics and metallurgy of the rare earths. Seven invited papers and 39 contributed papers were presented during the conference which attracted 150 participants. Of these, 14 were from the United States, 9 from France, 7 from Russia, 4 from Denmark, 3 each from Germany, Holland and Switzerland and 1 each from Brazil, Finland, Italy and Sweden. The remainder were from the United Kingdom.

There was much interest in most of the papers plus a great deal of discussion and exchange of information and ideas among the participants.

The papers presented at the conference will *not* be published in the form of conference proceedings. The authors were asked to publish the papers in appropriate journals whenever the results of their investigations are ready for publication. Long abstracts of the papers, however, were available to all the conferees.

GUEST LECTURERS

The invited papers in general consisted of two parts; a brief review of the latest developments in a particular area, and a summary of the speaker's own recent researches. The magnetic properties of rare-earth garnets were reviewed by R. F. Pearson of the Mullard Research Laboratories, Redhill, England. The behavior of the metals at high pressure was discussed by D. Block of the Laboratory of Electrostatics and the Physics of Metals, Grenoble, France. K. H. Hellwege of the Technical University of Darmstadt, Germany, talked about spectral studies of oxides and magnetically ordered materials. The four remaining talks were concerned with the rare-earth metals and alloys: anisotropy and magnetostriction by A. E. Clark (U. S. Naval Ordnance Laboratory, White Oak, Md.); electronic properties by W. E. Wallace (University of Pittsburgh, Pa.); physical metallurgy by K. A. Gschneidner, Jr. (Iowa State University, Ames, Ia); and spin waves by P. Wolf (International Business Machine Corp., Zurich, Switzerland).

RESEARCH REPORTS

Of the contributed papers, eight dealt with various aspects of spectral studies of rare earths: infrared spectroscopy of rare-earth magnesium nitrates and ethylsulfates; doping of rare earths in a variety of hosts, such as alkaline-earth fluorides, LaF_3, $LaAlO_3$ and YVO_4; the Faraday effect in rare-earth chloride solutions; the $M_{IV,V}$ emission spectra; and the correlation of spectral data with the structure of rare-earth phosphates.

Three papers dealt with neutron diffraction studies on cerium, terbium, and magnon-scattering from the magnetically ordered metals.

Mössbauer studies were discussed in four talks, which dealt with europium, rare-earth-iron Laves phases, gold intermetallic compounds, and the use of Coulomb-excited Mössbauer levels to study quadrupole moments.

Eight talks were concerned with magnetic properties. Subjects covered in these talks were: inclusion of the crystalline electric field gradient effects in the Weiss molecular field model to explain the magnetic behaviors of the heavy rare-earth metals; the magnetic properties of dysprosium, of noble metal and intra-rare-earth solid solution alloys, and of RFe_7, R_5Si_4 and R_5Ge_4 compounds; the magneto-crystalline anisotropy and the stability of magnetic moments in the metals; and the temperature dependence of the spin wave energies of terbium.

Nuclear magnetic resonance study of gadolinium Laves phases, and para-magnetic resonance investigations of rare earth-noble metal solid solution alloys, cobalt Laves phases, and rare earth-Group V compounds were the topics of four other papers.

The physical metallurgy of the rare-earth metals and alloys was discussed in four papers. The specific items covered dealt with a review of the recent metallurgical developments at the A. A. Baikov Metallurgical Institute in Russia, effect of impurities on microstructures, the erbium-hydrogen system, and preparation of rare earth-Group V compounds.

The eight remaining contributions covered a variety of topics, which do not fall into the above categories. These talks were concerned with: secondary electron emission, x-ray isochromat investigations, high and low temperature specific heats, elastic moduli, optical and electrical properties of thin metallic films, magneto-optic Kerr effect in $NdCo_5$, and MF_2-RF_3 phase diagrams (M = Ca, Sr, Ba and R = rare earth).

Because of space limitations the exact titles, authors and their affiliations have not been included in the above conference report. RIC, however, will be glad to furnish this information for a particular subject matter(s), so that you may contact the author or authors for more detailed information.

THE NAME OF THE GAME

The term rare earths has its origin with the early discovery of these elements. The word *rare* arises from the fact that these elements were discovered in scarce minerals. The word *earth* comes from the facts that they were first isolated from their ores in the chemical form of oxides and that the old chemical terminology for oxide is earth.

NUCLEAR APPLICATIONS

American Nuclear Society Meeting

Five papers of interest to rare-earth scientists were prsented at the 1966 Annual Meeting of the American Nuclear Society at Denver, Colo., June 20-23. These articles, described below, are available in Trans. Am. Nucl. Soc. 9, [1] (1966).

OAK RIDGE

C. F. Leitten, Jr. and R. J. Beaver report that the majority of the problems in the use of lanthanide oxides as neutron absorbing materials have been solved ("Technology and Performance of Lanthanide-Oxide Neutron Absorbers," p. 10). In particular, europium oxide now appears to be acceptable for such a use. The fabrication difficulties of Eu_2O_3 dispersions in steels have been overcome by new agglomeration processes and by a careful selection of dispersants and cladding materials which are free of silicon.

Additions of compounds such as MoO_3 or TiO_2 have been found to give europium oxide the corrosion resistance it needs for use in pressurized-water reactor systems. The irradiation behavior of both the hydration-resistant and the nonhydration-resistant europium oxide-containing specimens is acceptable.

BROOKHAVEN

The actual use of two lanthanide oxides as neutron absorbants is described by J. B. Godel and J. M. Hendrie ("High-Flux-Beam Reactor Control-Rod Blades and Drive Mechanisms," p. 10). The activity of the Brookhaven High Flux Beam Reactor is controlled by eight main control-rod blades containing a dispersion of 30 vol % Dy_2O_3 in stainless steel for most of the rod length and a dispersion of 30 vol % Eu_2O_3 at the high burnup tip. Eight auxiliary blades utilize an Eu_2O_3 absorber for the entire length. Additional information concerning the testing program and driving mechanisms is given in the article.

GENERAL ELECTRIC

Studies of the applications of rare-earth oxides in reactors were also made by W. G. Baxter and J. W. Tenhundfeld ("A Materials, Fabrication, and Design Feasibility Study for a High-Temperature, Uncooled, Articulating Control Rod," p. 12). Twelve materials were metallographically evaluated as cladants at temperatures of 1000-1040°C for periods up to 8000 hours. The best two materials were then used as cladding for a Ni-Dy_2O_3 cermet and tested for dimensional stability, microstructure and chemical stability.

A fabrication study was performed on the chosen clad Ni-Dy_2O_3 cermet. Fabrication of the core is also explained in the article. Included in this study were investigations on the wear in the hinge of the articulating rod and on the friction coefficient of the cladding material at elevated temperature.

HYDROXIDE SOLS

In a different area of nuclear science, S. R. Buxton, C. J. Hardy and M. H. Lloyd, all of Oak Ridge National Laboratory, reported on "The Preparation and Nature of Rare-Earth Hydroxide Sols, and Implications on Transplutonium Element Oxides," (p. 14). These investigators found that particles in the rare-earth hydroxide precipitate slowly change into rod-shaped crystals upon aging. A spontaneous change from a damp paste into a translucent sol occurs when a large proportion of the precipitate has been converted to the crystalline form.

Microspheres of controlled size may then be prepared by dehydration of the sol with an immiscible long-chain alcohol. Typical diameters of 50 to 200 μ, surface areas of 0.02 to 0.07 m^2/g, crushing strengths of around 650 grams for 150 μ diameters, and densities near the theoretical crystalline density were reported.

Trivalent actinide behavior is analogous to rare-earth behavior according to preliminary work.

ACTIVATION ANALYSIS

The fifth paper of interest is "The Determination of Terbium, Erbium, Ytterbium, and Yttrium by Neutron Activation Analysis," by General Atomics scientists F. M. Graber, H. R. Lukens, and K. Heydorn (p. 87). Pre-irradiation separation of the Tb - Er - Yb - Y fraction, followed by neutron activation is utilized in this method. Sensitivity was reported to be 0.8 μg of Er and 0.5 μg Y in one milligram of lanthanum with irradiations of 6 and 18 sec respectively in a thermal neutron flux of 4.3×10^{12} n/(cm^2 sec) and fission-spectrum neutron flux of 3.5×10^{12} n/(cm^2 sec). Detection of 0.0005 μg Tb and 0.01 μg Yb was achieved with an irradiation of five hours in a thermal-neutron flux of 1.8×10^{12} n/(cm^2 sec).

The procedure is rapid and straightforward and gives reasonable yields without serious fractionation of the rare-earth group, according to the authors. The major disadvantage appears to be in working with samples containing low levels of rare-earth elements where application of this method is not completely successful.

(Continued on Page 5)

Rare! Earthly Goofs

Vol. I, No. 3, Sept. 1966

Page 2, Col. 1

The story on Lunex failed to carry the location of the firm. Lunex Company is located at Pleasant Valley, Iowa.

Page 3, Photo caption

The name of Harvey Burkholder, general supervisor of the rare earth-separations pilot plant at Ames Laboratory (extreme right in back row) was inadvertently omitted from the photo caption.

Page 4, Col. 1

In the story entitled *Magnetism 1965*, the year should read 1964 in the second line of the first paragraph.

NUCLEAR APPLICATIONS

(Continued from Page 4)

RESERVE SAFETY SYSTEM

The use of gadolinium nitrate as a reactor poison in a shutdown system has been described in "Gadolinium Nitrate Injection as an Auxiliary Shutdown System for Savannah River Reactors" by L. A. Heinrick of E. I. du Pont de Nemours and Co., *Nucl. Safety 7*, 175-9: 184 (Winter 1965-1966).

In an actual test of the poison's speed and efficiency, it was found that a production reactor could be shut down within a few seconds after injection initiation and kept in that condition. Repurification of the moderator by circulation through an ion exchange system resulted in a poison removal rate said to be equivalent to 98% efficiency for the purification system.

The du Pont scientists conclude that the device is a reliable reserve safety system and that future operations of the reactor would not be impaired or seriously delayed by its use.

IN SPACE

Pm-147 has been proposed for use in a radioisotope-heated reaction control thrustor in a paper entitled, "Advanced Low-Thrust Propulsion Systems for Station Keeping and Stability Control of the NASA Manned Orbital Research Laboratory (MORL): Resistojets and Radioisotope Thrustors". The study was reported by M. Goodman of Douglas Aircraft Co. at the Fifth Electric Propulsion Conference of the Am. Inst. Aeronautics & Astronautics, San Diego, California, March 7-9, 1966. [CONF-660310-2]

The purpose of the radioisotope is to heat the propellant as it flows through the propellant tubes in the thrusting system. Pm-147 was chosen on the basis of its half life, radiation characteristics, availability and fuel form.

New Vacuum Gauge

A new gauge which measures the vacuum in "free" space, using beta-emitting ^{147}Pm, has been proposed by B. W. Schumacher, E. Aruja and H. R. Falckenberg, all of the Ontario Research Foundation, Toronto. A useful working range from 10^{-3} to 0.2 torr was found by the authors. An extension of the upper range from 10 to 10^{-13} torr is believed possible. [Paper presented at the Third International Vacuum Congress, Stuttgart, Germany, June 28 to July 2, 1965. (CONF-650643-2)]

RADIATION SHIELDING MATERIALS

Radiation shielding materials which contain either dysprosium or gadolinium provide the highest combined neutron and photon shielding efficiencies of any commercial product, according to W. C. Hall, president of Chemtree Corp., Central Valley, N. Y.

One of the new materials, containing 35% Dy and 40% Pb, has a neutron scatter cross section of about 60% that of lithium hydride for equal mass. The rare-earth product was found to yield a slightly better thermal neutron capture and markedly better photon attenuation.

The gadolinium-containing materials were reported to have a photon attenuation similar to that of tungsten on a mass basis.

BIRMINGHAM GROUP

(Continued from Page 1)

number. In extension of this work, wide ranges of temperature and pressure will be covered by using equipment which is now available. Though not primarily aimed at phase diagram determination, the programme gives rise to useful information in this field.

MEETINGS

They're Coming — Closer!

A partial list of invited speakers who have consented to participate in the Sixth Rare Earth Research Conference has been announced by Wallace C. Koehler, chairman. The speakers, their institutions and topics are listed below:

J. S. Anderson, Oxford University, Oxford, England
"Non-Stoichiometry and Defects in Solid State Chemistry of the Lanthanides"

A. J. Freeman, National Magnet Laboratory, M.I.T.
"Band Structure, Fermi Surface, and Electronic Properties of Rare-Earth Metals"

K. A. Gschneidner, Jr., Ames Laboratory
"Problems and Progress in Metallurgy of the Rare Earths"

K. H. Hellwege, Institute for Technical Physics, Darmstadt, Germany
"Optical Properties of Rare-Earth Compounds"

Howard E. Kremers, American Potash and Chemical Corp.
"Use of the Rare Earths"

D. B. McWhan, Bell Telephone Laboratories
"Magnetic Properties of Rare-Earth Alloys Under Pressure"

Therald Moeller, University of Illinois
"Current Problems and Studies in the Coordination Chemistry of Rare-Earth Metals Ions"

H. Bjerrum Møller, Atomic Energy Research Establishment, Riso, Denmark
"Inelastic Scattering of Neutrons by Spin Waves in Terbium"

H. Pauthenet, National Commission for Scientific Research, Grenoble, France
"Properties of Rare-Earth Metals Under Pressure"

P. N. Yocum, R.C.A. Laboratories
"Rare-Earth Chemistry and Laser Devices"

Kei Yoshida, University of Tokyo
"Spin Wave Theory of Rare-Earth Metals"

(Continued on Page 8)

Liquid Extraction Group of the Ames Laboratory

Chemical Engineering Group I at Ames Laboratory is interested in developing techniques for predicting the optimum operating conditions required to make a desired separation of rare earths in a multistage continuous countercurrent extractor. When this goal is reached, it will be possible to minimize the amount of expensive trial-and-error investigations required to determine the proper extraction conditions. Such techniques will also be applicable to other systems of interest to the Atomic Energy Commission.

LIQUID EXTRACTION GROUP — Standing from left are Roger F. Sebenik, Thomas C. Owens, Richard W. Rahn and S. Edward Mead. Seated from left are Terry G. Lenz, Dr. Morton Smutz and S. Gopala Krishnan Nair.

Because the thermodynamics of concentrated solutions of mixed electrolytes is not well understood, it is necessary to correlate equilibrium data empirically. The Group has successfully correlated equilibrium data for the tributyl phosphate (TBP) - HNO_3 - $R(NO_3)_3$ - H_2O system and is doing similar work with the di (2 ethyl hexyl) phosphoric acid (D2EHPA) - HCl - RCl_3 - H_2O system.

The problem of determining the separation that can be made under given operating conditions using TBP as the solvent has been solved by computer methods. Research in progress is concerned with optimizing the conditions based on the highest return on the investment.

It is well known that D2EHPA extracts many solutes by so-called "liquid ion exchange." This Group has found that one or more other mechanisms of extraction also take place at even moderate concentrations. This is particularly true for rare-earth nitrates and perchlorates.

Simulated column runs have been used to determine the operating conditions required to produce a lanthanum product of greater than 99.8 percent purity starting with a didymium chloride mixture. Two extraction cascades were employed.

A mixer-settler extractor has been developed specifically for the D2EHPA - diluent - RCl_3 - HCl - H_2O system. This extractor will be used to obtain a high purity lanthanum product.

"Indeed, We Haven't Any"

The Research Materials Information Center (RMIC) at Oak Ridge National Laboratory has asked our help in obtaining the following materials.

Rare Earth Material	Purity	Form
Ce Metal	4N	SX*
hydroxides	—	SX*
oxyfluorides	—	SX*

*SX - single crystal

If you can shed some cerium, hydroxides or oxyfluorides on the subject, please correspond directly with Dr. T. F. Connally, Research Materials Information Center, Oak Ridge National Laboratory, Oak Ridge, Tenn. 37830. We would appreciate a carbon copy of your correspondence.

Rare Earths In the News

Transparent Ceramic

A new yttria-thoria ceramic has been developed at General Electric. At a meeting of the American Ceramic Society at University Park, Pa., Dr. R. C. Anderson and Dr. P. J. Jorgensen stated that the ceramic is transparent and can withstand temperatures in excess of 2200°C.

This material contains 10 mol % of thoria dissolved in cubic yttria. The microscopically small pores which scatter light are removed from between the powder particles by heat treating. Polishing results in a ceramic with an "exceptional transparency" to visible and infrared light.

The transmission cutoff occurs in the ultraviolet range at 0.24 micron and at about nine microns in the infrared range. Light absorption is low and the transmitted light has a minimum distortion.

"STATE OF THE ART"

Current uses of rare-earth phosphors in the lighting and TV industries are outlined in a recent *Chemical Week* article. The review, "Rare-Earth Future Glows," pp. 79-81 of the Oct. 8, 1966 issue, describes the improvements in mercury vapor lamps, fluorescent tubes and color TV when rare-earth phosphors are used.

The expansion in rare-earth production, brought about by the new demands for rare-earth oxides, is also described (see below). A brief survey of four of the leading suppliers of rare-earth products includes their present facilities and methods of production, and their plans for expansion in the future.

Those of you who are interested in this aspect of rare-earth technology will find this review a concise summary of the "state of the art."

(Continued on Page 7)

Rare Earth — Cobalt Magnets

The magnetic behaviors of rare earth-cobalt, RCo_5, intermetallic compounds have been reviewed by R. Lemaire of the Laboratory of Electrostatics and Physics of Metals, Grenoble, France, in the September, 1966 issue of *Cobalt*, No. 32, pp. 132-140. In this article, "Magnetic Properties of the Intermetallic Compounds of Cobalt with the Rare Earth Metals and Yttrium," a brief survey of the known rare earth-cobalt phase diagrams, crystallographic data and magnetic properties is presented.

Levitation melting was used to prepare the RCo_5 compounds, since these alloys react with all the common refractory metals and oxides which might be used as crucibles.

The major portion of the article deals with the magnetic properties of the RCo_5 compounds, especially $CeCo_5$, $NdCo_5$ and $TbCo_5$. Magnetization data as a function of temperature, Curie temperatures (which range from 464°C for $CeCo_5$ to 747°C for $SmCo_5$ and $TmCo_5$) and the magnetic structures are discussed. For $CeCo_5$, the Ce atom has no magnetic moment, suggesting it is tetravalent, and the entire magnetization of the compound is due to the Co atoms. For $NdCo_5$, the magnetic moments of the Nd atoms are aligned parallel to those of the Co atoms. But for $TbCo_5$ the magnetic moments of the Tb atoms are aligned antiparallel to those of the Co atoms. The direction of easy magnetization for the $NdCo_5$ and $TbCo_5$ compounds at low temperatures (below −50° and +100°C, respectively) is in the basal plane of these hexagonal compounds, but as the temperature is raised the direction rotates, such that above 20° and 180°C, respectively, the direction of easy magnetization is parallel to the *c*-axis.

Another paper on this subject is to be published in a later issue of *Cobalt*.

Oxidation Resistant Yttrium

Protection of yttrium metal articles from oxidation and corrosion at temperatures up to 900°C for at least 60 hours has been obtained through a process patented by D. R. Wilder and C. D. Wirkus, Ames Laboratory, Ames, Iowa, for the Atomic Energy Commission. [Pat. No. 3,266,928, August 16, 1966].

A mixture of vanadium oxide and aluminum oxide suspended in a low-boiling liquid medium is applied to the yttrium article to be coated. This material is then fired at 1100 to 1250°C, resulting in a crystalline glass coating. The yttrium surface which is to be coated does not need to be precleaned, although better results are obtained when it is.

RARE EARTHS IN THE NEWS

(Continued from Page 6)

Expand Production Facilities

Three companies in the rare-earth industry have announced the expansion of production facilities. American Potash and Chemical has a new rare-earth solvent extraction unit under construction at its West Chicago, Ill., plant which will double the firms capacity for the production of both yttrium and europium oxide upon completion in the Spring of 1967.

Molybdenum Corp. of America has recently completed expansion of its capacity for europium oxide production at its Mountain Pass, Calif. site from 12,000 to 20,000 pounds annually. Also planned at the Mountain Pass location is the expansion of the company's rare-earth flotation mill from 30 to 50 million pounds per year.

At Louviers, Colo., Yttrium Corp. of America has begun operation of a production facility for 180,000 pounds of pure yttrium oxide annually. Also under construction are facilities for producing high-purity lanthanum, praseodymium, and neodymium oxides.

Liquid Lasers

A new type of liquid laser has been developed by A. Heller and A. Lempicki of General Telephone and Electronics Laboratories (GT&E), Bayside, New York. Using neodymium oxide dissolved in selenium oxychloride, an energy output of about 100 times greater than that previously achieved by liquid lasers was obtained. The energy produced is said to be comparable to that of solid-state lasers of similar size under identical operating conditions. In some modes, the GT&E laser solution's gain is so high that laser action is achieved without the usual end-mirrors.

The use of selenium oxychloride as solvent is stated as the basic principle underlying the high energy output of this laser. Such a solvent does not contain light atoms ($Z<8$) which cause dissipation of energy by vibrational losses. This effect was demonstrated by the enhancement of the luminescence of neodymium in aqueous solution when deuterium was substituted for hydrogen.

Liquid lasers have several inherent advantages. With no practical limit on a liquid laser's length, the ultimate energy output of the liquid laser may be higher than that of crystalline lasers, since the energy output of a laser is related to volume of active medium. Liquid laser material may be circulated to provide cooling and thus overcome the problem of heat build-up in laser mediums. In addition the liquid laser has the capacity to repair itself, even after heat produces bubbles.

Further information concerning the Nd^{3+}: $SeOCl_2$ liquid laser is available in *App. Phys. Letters 9*, 106-110 (1966).

RANKS 28th IN ABUNDANCE

Cerium, which is the most abundant rare earth, ranks 28th in the abundances of the naturally occuring elements and is more plentiful than beryllium, cobalt, germanium, lead, tin, or uranium.

Reports, Brochures, Booklets

RARE EARTH TECHNICAL BULLETIN

We have recently received a technical bulletin, *Yttrium and the Rare Earths*, published by the Michigan Chemical Corp.

The technical bulletin lists rare-earth oxides, metals and salts and includes a description of these plus information on their properties, uses, handling precautions, and shipping regulations.

This new technical bulletin may be obtained by writing to:

Michigan Chemical Corp.
2 North Riverside Plaza
Chicago, Ill. 60606

1965-66 Publications Book

The Ames Laboratory 1965-66 *List of Publications* is available for distribution.

The booklet lists more than 200 research and development (R&D) reports and journal publications in the areas of chemistry, engineering, physics and metallurgy which issued from the Ames Laboratory during Fiscal Year 1966. A significant number of these papers and reports deal with rare-earth investigations.

Information on how to obtain copies of R&D reports, plus an order form for requesting reprints of journal publications from the Laboratory appear on the inside, back cover of the booklet.

The booklet will be distributed to RIC subscribers on request.

If your institution publishes a similar list, we would be happy to announce it in this column.

Rare Earths From Apatite

Scientists of the U. S. Geological Survey, Washington, D. C., have indicated [*Chem. and Eng. News* 44, No. 44, 52 (1966)] that apatite, the principal mineral in phosphate rock, could be an important industrial source of the rare earths. Although rare earths constitute only 0.01 - 0.1% of the mineral, large amounts of apatite are processed yearly in wet-process phosphoric acid production, thus significant quantities of rare earths are available for potential recovery.

An additional bonus to this source lies in the fact that the cost of mining, beneficiating, processing and solubilizing the rare earths would already be paid for in the course of phosphoric acid production.

Marine apatite contains a relative enrichment of the middle-and higher-atomic weight lanthanides. It is estimated that 8.5 million tons of apatite will be processed in the United States during 1966 for phosphoric acid. More than 5000 tons of rare earths could be extracted from this source.

[Ed. note: Typpi Oy, a nitrogen plant at Oulu, Finland, has for many years produced rare earths by extraction from apatite].

RARE-EARTH RESEARCH

(Continued from Page 2)

ENGLAND

At the University of Birmingham I visited with Drs. G. V. Raynor, R. I. Harris and their co-workers. A more complete description of their research interests are presented in our column *Rare-Earthers Around the World*, page 1.

Our discussions dealt with the variation of lattice parameters of solid solution alloys (intra-rare earth, and rare earth-gold, -silver, -palladium, and -thorium) and the crystal chemistry of intermediate phases.

The last few days in Europe were spent at the Rare-Earth Conference in Durham, England. A complete report of this aspect of the trip is given on page 3.

NOT SO RARE

Twenty five percent of the naturally occuring elements are scarcer than thulium. Thulium is more plentiful than cadmium, gold, iodine, mercury, platinum, or silver.

MEETINGS

(Continued from Page 5)

Dr. Alvin Weinberg, Director of Oak Ridge National Laboratory, will be the banquet speaker. ORNL is co-sponsor of the conference along with the Air Force Office of Scientific Research, Directorate of Chemical Sciences.

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