RARE-EARTH INFORMATION CENTER NEWS

ENERGY AND MINERAL RESOURCES RESEARCH INSTITUTE
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1977 IR-100

Phosphors and magnets constitute the two rare earth products that placed in *Industrial Research's* IR-100 list for 1977 [*Industrial Research* **19,** (10) 60-4 (1977)]. The IR-100 represent the top 100 products of 1977 as rated by *Industrial Research.* Brief descriptions of this year's place winners are given below.

The rare earth-containing phosphors strontium chlorapatite doped with europium (+2) and yttrium oxide doped with europium (+3) represent two of the three phosphors present in a new fluorescent lamp which is energy efficient and provides better "seeability". Research has shown that the human eye responds more to three colors (wavelengths): blue-violet (450 nm), green (540 nm) and orange-red (610 nm). When combined, a very efficient white light results because of the reduced ultra violet and infrared radiation. Strontium chlorapatite: Eu^{2+} provides the blue-violet and yttrium oxide: Eu^{3+} provides the orange-red coloration.

Rare earth magnets have replaced the solenoid in control valve drivers which electromechanically drive control valves on hydraulic power actuators like those used in aircraft hydraulic systems. The new drivers require less power to operate and eliminate the need for a secondary hydraulic power system resulting in an order of magnitude cost savings.

RE's Used in Contact Printing

The use of amorphous GdFe, TbFe and DyFe alloy films for contact printing without a bias field or thermal transfer contact printing has been studied by N. Imamura, Y. Mimura and T. Kobayashi [*J. Appl. Phys.* **48,** 2634-7 (1977) and *Japan J. Appl. Phys.* **15,** 715-6 (1976)]. The films contained 15 to 30% rare earth, the compensation composition at which the easy axis of magnetization is perpendicular to the film plane. The stray magnetic fields from the magnetic tape or card are large enough to "write" information into the amorphous alloy films. This information can then be magneto-optically read out using the polar Kerr effect. The quality of a printed pattern was found to decrease with increasing film thickness. The low coercivity of the GdFe films allows contact printing with no bias field. The coercivities of TbFe and DyFe are too high for them to be of any use in the same manner as the GdFe film. However, the Curie temperature of the DyFe alloy is low (60° C) and its coercivity decreases with increasing temperature to the extent that near 60° C the stray fields from the magnetic tape or card are large enough to "write" information on the DyFe film. Therefore the DyFe alloy is suitable for contact printing if a thermal transfer is used.

Unusual Isotope Effect

H. Kruger, O. Lutz and H. Oehler have used NMR spectroscopy in aqueous solution to determine the nuclear magnetic moments and ratios of quadrupole moments for ^{138}La and ^{139}La [*Phys. Letters* **62A,** 131-2 (1977)]. While measuring the dependence of the Larmor frequencies and linewidths as a function of concentration of various lanthanum salts in H_2O and D_2O, the lanthanum solvent isotope effect was determined. The value obtained indicates that the solvent isotope effect anomalously decreases with increasing atomic number of the IIIb elements.

CONTRIBUTORS

Five companies renewed their support of RIC in the third quarter of fiscal year 1978, bringing the total number of benefactors to 35 so far. Contributions were received from Apache Chemicals, Inc. USA for the second year, British Flint and Cerium Manufacturers, England, and Companhia Industrial Fluminense, Brazil, both six year contributors, Colt Industries-Crucible Inc., USA, for the fourth year and Santoku Metal Industry Co. Ltd., Japan, an eight year supporter of the Center. Response has been slow in the third quarter following a record breaking first half year, however we look for a strong finish in 1978.

Deformation Mechanism

Using X-ray diffraction, optical and scanning electron microscopy and high and low field magnetic measurements, H. H. Liebermann and C. D. Graham, Jr., attempt to determine the mechanism of plastic deformation in dysprosium single crystals [*Acta Metallurgica* **25,** 715-20 (1977)]. They found the mechanism to be $\{10\bar{1}2\}\ <10\bar{1}\bar{1}>$ mechanical twinning and that it was a primary twinning system. The lowering of the magnetostatic and magnetocrystalline anisotropy energies resulting from twin formation is thought to be the driving force for the deformation. Simplified energy considerations support this explanation. Other possible causes for deformation include the magnetostrictive strains in high fields exceeding the elastic limit of the sample or the mechanical torque forces acting on the sample due to misalignment of the hard axis with the applied field exceeding the sample yield stress.

Separation, Preparation Application, Toxicology

Book number B2 of *System 39, Rare Earth Elements, the Gmelin Handbuch der Anorganischen Chemie* has been published by Springer-Verlag in 1976. This volume is 283 pages in length and costs DM 585, - (~$239.90). This book features English table of contents, preface and margin notes.

The four topics covered in Book B2 are separation of the rare earths, preparation of rare earth metals, application of the metals and toxicology. Types of separations discussed include fractional precipitation, crystallization, hydrolysis and decomposition; selective dissolution, oxidation and reduction; electrolysis, amalgam extraction, ion exchange and solvent extraction. The chapter on metal preparation covers metallothermic, electrolytic and other reduction methods; preparation of special forms, i.e. thin film, flake, single crystal; refining processes; purity testing; storage, shaping and handling. Rare earth applications reported include use in pyrophoric alloys, cast iron, steel, non-ferrous alloys, welding, solder, brazing alloys, magnets, X-ray filters, cathodes, getters, nuclear technology, catalysts and hydrogen storage. Last is the chapter concerning the toxicology of the rare earths.

R_2O_3 + Ti ?

Citing the fact that there are no commercially available titanium alloys which contain insoluble dispersed particles for improved high temperature mechanical properties, R. C. Waugh has undertaken research to determine the high temperature compatability of 16 oxides, which included 14 rare earth oxides, with titanium [*Int. J. Pwdr. Met. Pwdr. Tech.* **12,** 85-9 (1976)]. Titanium—10% oxide compacts containing Dy_2O_3, Er_2O_3, Eu_2O_3, Gd_2O_3, Ho_2O_3, La_2O_3, Lu_2O_3, Nd_2O_3, Pr_6O_{11}, Sc_2O_3, Sm_2O_3, Tb_2O_3, Y_2O_3 and Yb_2O_3 were subjected to differential thermal analysis (DTA), electron microscopy and electron microprobe analysis. DTA revealed a definite exothermic reaction between Pr_6O_{11} and Tb_2O_3 [Editor's note: The Tb_2O_3 probably contained some Tb_4O_7 to give this exothermic reaction.] and the titanium matrix thereby excluding these oxides from further consideration. The remaining compacts were vacuum sintered for 4 hours at 1066° C. Electron microprobe analysis showed that Gd_2O_3, Sm_2O_3, La_2O_3, Y_2O_3, Ho_2O_3, Sc_2O_3, Yb_2O_3, Er_2O_3 and Eu_2O_3 reacted with the titanium matrix at a slower rate. Unfortunately any reaction is unsatisfactory and so these oxides are also eliminated as dispersants. Only Lu_2O_3, Nd_2O_3 and Dy_2O_3 displayed no evidence of reaction with the titanium matrix, which makes them promising candidates for dispersion strengthening of titanium alloys.

Physical Properties of Chalcogenides

The Russian book *Fizicheskie Svoistva Khal'kogenidov Redkozemel'nykh Elementov (Physical Properties of the Chalcogenides of Rare Earth Elements),* V. P. Zhuze, Ed., Nauka Publishers, Leningrad (1973) has been translated to English and is available from the National Technical Information Service, U.S. Department of Commerce, Springfield, Virginia 22161 as report number DOE-tr-6 (December 1977). The translation is 526 pages in length. The cost of a paper copy is $15.50 and microfiche is $3.00.

The authors attempt to systematize and collate the huge volume of theoretical and experimental data that has been generated due to the many interesting properties and possible applications inherent in the chalcogenides of the rare earths. Physical and physico-chemical properties discussed include phase diagrams; crystal structures; valence states; methods of preparation; single crystal growth and identification; temperature, pressure, thermomagnetic and electromagnetic effects on the electrical conductivity; superconductivity; heat capacity; thermal expansion; thermal conductivity; magnetic properties and magnetic ordering; exchange interactions and optical properties. Applications include thermo-electric and magneto-hydrodynamic transducers, nuclear cooling, superconductors, reflective coatings, phosphors, lasers, magneto-optical storage, optical communications, magnetic materials and semiconductor devices. This review includes 719 references.

Lasers Initiate New Series

Lasers and Excited States of Rare Earths by R. Reisfeld and C. K. Jørgensen is the title of volume one of a new series entitled *Inorganic Chemistry Concepts,* edited by C. K. Jørgensen and published by Springer-Verlag, Heidelberg (1977). This clothbound volume contains 226 pages and costs $29.50 (DM 64,-).

In chapter one, analogies and differences are drawn between monatomic entities and condensed matter with respect to spherical symmetry, minor deviations from spherical symmetry, intershell transitions and electron transfer bands.

Chapter two discusses various aspects of rare earth lasers including spontaneous and stimulated emission, three- and four-level laser systems, oscillation modes, optical pumping threshold and laser output. Examples are given of various rare earth gaseous, liquid and solid state lasers in general and neodymium-doped crystal, glass and glass ceramic lasers, in particular.

The discussion of chemical bonding and lanthanide spectra in chapter three covers the nephelauxetic effect, photo-electron spectra, hypersensitive pseudoquadrupolar transitions and the Judd-Ofelt parametrization.

Chapter four deals with energy transfer. Transfer probabilities, migration of excitation, inhomogeneous broadening and phonon-assisted energy transfer are discussed and examples are given.

Applications and suggestions constitute chapter five. Among the applications the most notable possibilities are induced thermonuclear reactions and advanced communication systems.

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K. A. Gschneidner, Jr.. . .Editor
Bernie Evans. . .Staff Writer

Possible $LaNi_5$ Substitute

C. E. Lundin and F. E. Lynch of the Denver Research Institute have developed a new intermetallic nickel compound which appears to be a viable alternative to most of the other hydrogen storage materials under consideration—including $LaNi_5$ [*E/MJ* **178,** [7] 43, 47 (1977)]. Their compound, $(La_{0.67}Nd_{0.25}Pr_{0.08})$ Ni_5, has the advantages of being less costly, having abundant raw materials, does not contain co-occurring metals (e.g. Ce) which inhibit hydrogen absorption or desorption, absorbs six hydrogen atoms per molecule, is not contaminated in air as much as other alloys under consideration and requires pressures only slightly higher than $LaNi_5$. Another advantage is safety, since cryogenics and extreme pressures are not used, and container puncture or ignition is much less of a hazard.

Applications of (La, Nd, Pr) Ni_5 could include solar heating and cooling of homes, leveling of peak load demands at electric utility companies, a nonpolluting combustion engine, hydrogen gas purification, compression and storage, and utilization of natural heat sinks.

Ce Aids Holograms

High optical sensitivity has been observed in cerium-doped strontium barium niobate (SBN:Ce) crystals by K. Megumi, H. Kozuka, M. Kobayashi and Y. Furuhata [*Appl. Phys. Letters* **30,** 631-3 (1977)]. Introduction of cerium gave rise to a four order of magnitude increase in recording sensitivity and an approximately eightfold enhancement in saturation efficiency. The increased sensitivity is thought to be due to the high quantum yield for carrier generation processes. Another advantage is the symmetrical behavior of the storage and erasure cycles. When kept in darkness at room temperature, the decay time constant of holograms stored in SBN:Ce was found to be one month. A longer decay time could be expected if the crystal were treated under higher oxidation conditions to reduce any oxygen deficiencies formed during crystal growth. The authors feel that holographic storage in SBN:Ce is feasible. *According to the authors it is the most sensitive electro-optic crystal to date and has great potential for high speed rewritable optical memory applications.*

Hume-Rothery Award

K. A. Gschneidner, Jr.

K. A. Gschneidner, Jr. has been named the recipient of the 1978 William Hume-Rothery Award. This annual award was created in 1972 by the Metallurgical Society of AIME to honor an outstanding scientific leader in recognition of scholarly contributions to the science of alloys.

Educated at the University of Detroit and Iowa State University (Ph.D. 1957) Gschneidner conducted research at the Los Alamos Scientific Laboratory and then at the University of Illinois before joining the Ames Laboratory and Iowa State University in 1963. He is currently the Assistant Program Director for Metallurgy and Ceramics at Ames Laboratory-DOE, Professor of Materials Science and Engineering and Director of the Rare-Earth Information Center, Iowa State University. Current research interests include the alloy theory of metallic systems, preparation of high purity rare earth metals and single crystals of both metals and intermetallic compounds, low temperature heat capacity, magnetic susceptibility and electrical resistivity of rare earth solid solution alloys.

Mg Alloy Phase Diagrams

G. V. Raynor has critically summarized the available knowledge on the constitutions of a number of potentially important magnesium-based alloy systems, many of which contain one or more rare earths [*International Metals Reviews,* No. 216, 65-96 (June 1977)]. Citing renewed interest in the development of high strength lightweight magnesium alloys and the varying degree of completeness and accuracy of available constitutional studies the present review was aimed at those systems with a high potential for application. Ternary phase diagrams are discussed for the alloys of magnesium and yttrium with manganese or zinc; magnesium and neodymium with manganese, nickel, yttrium or zinc; and, magnesium and cerium with aluminum, lanthanum, silicon, manganese, calcium or nickel. The quaternary systems covered which included rare earths are magnesium-neodymium-yttrium-zinc, magnesium-neodymium-manganese-nickel and magnesium-cerium-cobalt-manganese.

Amorphous Materials Surveyed

Recent research concerning amorphous magnetically ordered metals and alloys which can be prepared by evaporation or sputtering and chemical or electrodeposition has been surveyed by G. Dietz, in order to obtain information about the atomic ordering in amorphous materials, the influence of structural disorder on magnetic properties and possible applications as soft magnetic materials, bubble materials and for magneto-optical writing and erasing [*J. Magnetism and Mag. Mater.* **6,** 47-51 (1977)]. The 131 references include articles on binary alloys of Gd, Ho, Tb, Dy, Y, Lu, Er, Tm and Yb with Co, Fe, Ni and Cu and ternary alloys of Gd and Dy with Co, Mo, Cu, Au, Cr, Fe and Ni. In addition, the studies on the uniaxial magnetic anisotropy of these alloys were summarized. The author concludes that the main cause of the observed uniaxial anisotropy should be short range atomic ordering.

CF in RE Compounds

Crystal field effects in rare earth intermetallic compounds is the subject of a recent review by W. E. Wallace, S. G. Sankar and V. U. S. Rao [*Structure and Bonding* **33,** 1-55 (1977)]. In updating an earlier summary made in 1973 the authors briefly review the nature of exchange interactions and crystal field effects and the mathematical treatment of a single J state, the effects of J mixing and the effect of an external or exchange field. This approach is then related to experimental evidence obtained from magnetic susceptibility, heat capacity and free energy, neutron inelastic scattering, spin disorder resistivity and magnetic anisotropy. Experimental data for specific families of rare earth intermetallic compounds including $RA1_2$, $RA1_3$, RNi_2, RNi_3, RNi_5, RCo_2, RCo_5, R_2Co_{17}, RFe_2 and RH_2 are examined. Special mention is given to the crystal field effects in samarium compounds, i.e. spin reorientation in $SmFe_2$ and the magnetocrystalline anisotropy of $SmCo_5$. 167 references are included.

Superalloy Metallurgy

Powder metallurgy techniques as applied to superalloys is the subject of a review by J. S. Benjamin and J. M. Larson [*J. Aircraft* **14,** 613-23 (1977)]. At present superalloy powder metallurgy can be divided into three catagories. These are conventional techniques, thermoplastic processing and mechanical alloying. The development of mechanical alloying is of the most interest to rare earthers, since this process has made possible the production of rare earth oxide-dispersion strengthened superalloys unattainable by other techniques. The mechanism of the oxide dispersion is briefly reviewed. Three commercially-produced, mechanically-alloyed, nickel-based superalloys which contain Y_2O_3 for dispersion hardening are discussed with respect to structural characteristics, physical properties, chemical properties and mechanical properties. These increasingly complex alloys offer possible advantages in aircraft turbine vanes, burner cans and turbine blading applications.

$YFeO_3$ Zaps Water

The possibility of photoelectrolyzing water with illuminated semiconducting electrodes as a means of solar energy conversion has caused M. A. Butler, D. S. Ginley and M. Eibschutz to study the use of $YFeO_3$ electrodes for photoelectrolysis [*J. Appl. Phys.* **48,** 3070-2 (1977)]. A model has related the hydrogen production to the electronegativities of the electrodes and predicted that rare earth orthoferrites would have improved zero bias operation characteristics over currently used materials. The photoresponse was observed only when $YFeO_3$ was positively biased, however because of its improved flatband potential $YFeO_3$ required less bias for operation. The electrode showed no sign of deterioration although the long term stability was not specifically studied. Low quantum efficiency in $YFeO_3$ can be modified by improving its purity and/or optimizing dopant levels to enhance the carrier concentration. This study indicates $YFeO_3$ to be a promising candidate as a photoanode for the practical conversion of solar energy to chemical energy by the photoelectrolysis of water.

Room Temperature Blue Light Laser

L. Esterowitz, R. Allen, M. Kruer, F. Bartoli, L. S. Goldberg, H. P. Jenssen, A. Linz and V. O. Nicolai believe they are the first to report room temperature operation of a solid state laser in the blue region [*J. Appl. Phys.* **48,** 650-2 (1977)]. A 0.2% Pr-doped $LiYF_4$ crystal was longitudinally pumped using a pulsed dye laser. Laser emission occurred at 479 nm and required a threshold energy density of 8 J/cm^2. The authors plan to measure the conversion efficiency once the experimental parameters have been optimized. Possible applications include the conversion of long-pulse dye laser excitation to Q-switch output in the blue spectral region.

Russian RE Semiconductor Bibliographies

In the past few months RIC has received *Redkozemel'nye Poluprovodniki. Tekuschchaya Bibliograficheskaya Informatsiya 6* [*Rare Earth Semiconductors. Current Bibliographic Information, No. 6*] V. P. Zhuze, editor, Fiziko-Tekhnicheskii Institut im. A. F. Ioffe, Akademii Nauk SSSR, Leningrad (1977), and also No. 7, which carries the same title, editor and publisher as No. 6. The sixth bibliography on semiconductors has 774 citations while the seventh has 632. The references are printed in their original language—English, Russian, French, etc. A brief subject index (20 entries) is also included in each volume.

RE's in the News

World's Most Powerful Laser

A neodymium-doped glass laser, called Shiva, has been constructed at the Lawrence Livermore Laboratory (LLL) and initial tests have revealed it to be the world's most powerful laser. 10,200 joules of laser light energy was produced in a 10^{-9} second pulse almost tripling the output of LLL's Argus laser. The Shiva laser is to be used in inertial confinement fusion experiments in which scientists hope to demonstrate a significant thermonuclear burn using deuterium and tritium targets.

RIC Documents Available

IS-RIC-4 *Rare Earth Metals in Steels,* Nancy Kippenhan, Karl A. Gschneidner, Jr., March 1970.

IS-RIC-5 *Thermochemistry of the Rare Earth Carbides, Nitrides and Sulfides for Steelmaking,* Karl A. Gschneidner, Jr., Nancy Kippenhan, August 1971.

IS-RIC-6 *Thermochemistry of the Rare Earths, Part 1. Rare Earth Oxides, Part 2. Rare Earth Oxysulfides, Part 3. Rare Earth Compounds with B, Sn, Pb, P, As, Sb, Bi, Cu and Ag,* Karl A. Gschneidner, Jr., Nancy Kippenhan and O. Dale McMasters, August 1973.

IS-RIC-7 *Selected Cerium Phase Diagrams,* Karl A. Gschneidner, Jr., Mary E. Verkade, September 1974.

Reports listed above are available without charge from the Rare-Earth Information Center, Energy and Mineral Resources Research Institute, Iowa State University, Ames, Iowa 50011 or from Molycorp, Inc., Metallurgical Sales, No. 4 Gateway Center, Pittsburgh, PA 15222.

Rare-Earth Information Center
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Iowa State University
Ames, Iowa 50011

RARE-EARTH INFORMATION CENTER NEWS

ENERGY AND MINERAL RESOURCES RESEARCH INSTITUTE
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University of New South Wales Group


G. V. H. Wilson


D. H. Chaplin


S. J. Campbell


G. H. J. Wautenaar


T. J. McKenna

In 1972 a small group of workers led by Professor G. V. H. Wilson at the Physics Department, Royal Military College, Duntroon (University of New South Wales), Australia, began a study of gadolinium. The aim was to extend conventional AC susceptibility (χ) measurements to low magnetic fields ($<$850A/m or $<$11Oe) by employing phase sensitive detectors, and to develop temperature modulation techniques. The main intention was to precisely characterize the magnetic behavior above and below the critical point of an order-disorder transition. Gd was chosen for initial studies because of departmental interest in rare earth magnetism and because it is a ferromagnet with a convenient room temperature Curie point.

K. R. Sydney, under the supervision of Professor Wilson and Dr. D. H. Chaplin, investigated the AC susceptibility, the thermal derivative of χ (via temperature modulation experiments) and the DC magnetization of Gd near the critical temperature. The high sensitivity of the experiments enabled previously unobserved fine structure in the magnetization curves to be examined. Comparison between the techniques has led to a better understanding of the nucleation of domains whereby the behavior of the low-field AC susceptibility is well described by a simple model which includes a temperature dependent magnetic relaxation. In addition, the relaxation is associated with the onset of an impurity magnetic aftereffect.

G. H. J. Wantenaar and Dr. S. J. Campbell have developed both a technique of transient enhancement (TE) of AC susceptibility and an application of the AC specific heat method to bulk samples. By imposing a second time-varying field during AC susceptibility measurements, the TE technique enables the diffusion of domain-wall pinning centers to be studied, thus acting as a sensitive indicator of domain nucleation. This is a particularly important advantage for magnetic critical phenomena studies near T_c. Below T_c, TE has resolved the activation energies of different impurities in the gadolinium samples. This method is therefore considered a sensitive probe which can identify impurities in fer-

(continued on page 6)

Rare Earth Prize

Dean J. B. Gruber, Conference Chairman for the 14th Rare Earth Research Conference to be held June 25-28, 1979, at North Dakota State University, Fargo, ND (see page 3), has announced that the Conference will award, for the first time, the Rare Earth Prize to that individual deemed to have made outstanding contributions toward advancing rare earth science and/or technology. The prize will consist of a certificate, a medallion and possibly a cash award. The Conference organizers hope to establish a tradition for future rare earth research conferences by inaugurating the presentation of this award during the Plenary Session at the beginning of the Conference.

Nominations with supporting biographical data and a cover letter citing specific achievements should be sent to the Chairman of the Selection Committee, Professor W. J. James, Graduate Center for Materials Research, University of Missouri-Rolla, Rolla, MO 65401, no later than January 15, 1979.

Linear Actuators Improved

A. S. Rashidi, of the Crucible Magnetics Division of Colt Industries, has done a comparative evaluation of linear actuators which contain either alnico or samarium cobalt (Sm-Co) permanent magnet [*Control Engineering* **24,** (11) 56-8 (1977)]. The Sm-Co permanent magnet exhibited several advantages. Its higher coercivity allows for a reduction in the length of the magnet and permits the magnet to be used on the air gap boundary. Its higher energy product allows for a reduction in magnet volume resulting in a magnet which weighs eight

(continued on page 6)

Yb

1878

Congratulations to ytterbium on the 100th anniversary of its discovery by Jean-Charles Galissard de Marignac. Perhaps best known for his accurate determinations of atomic weights, Marignac began working with the rare earths in 1840. While a professor of chemistry at the Geneva Academy, he continued his research in a dimly lit laboratory. In 1878 Marignac heated some erbium nitrate obtained from gadolinite until it decomposed. From this material he extracted a red colored oxide which he called erbia and a colorless oxide that he named ytterbia after Ytterby, the town nearby where gadolinite was discovered. This was not the final step for ytterbium. One year later L. F. Nilson isolated scandia from ytterbia and twenty-nine years later in 1907, Georges Urbain separated ytterbia into two oxides which he called neoytterbia to preserve the name Marignac had given to the mixture, and lutecia. However, the name which Marignac had given has survived and today the element he discovered in 1878 is known as ytterbium.

Eu Photochemically Separated

A year ago we noted that T. Donohue had achieved the photochemical separation of europium using laser radiation [*RIC News* **XII,** (2) 4 (1977)]. Subsequent research has increased the understanding of this method of separation [*J. Chem. Phys.* **67,** 5402-4 (1977)]. Basically, europium is reduced with photons to the +2 state, and reacts to form an insoluble sulfate which is filtered from the solution to complete the separation. Donohue observed a much better reduction if Eu was irradiated in its charge transfer band. Also, the inclusion of sulfate ions in the solution allowed the precipitate to form homogeneously. No relation was observed between the separation factor and the light source or the wavelength. The separation factor varied from around 1 for Eu/Pr to > 200 for Eu/Tm and was related to the ionic radius of the Eu^{2+} ion. This type of separation could be of importance in the reprocessing of nuclear fuel, in that fewer chemicals are used which would reduce the amount of radioactive waste to be stored.

Fluorides and Chlorides

Various compounds of the rare earths with fluorine and chlorine are treated in books C3 and C5, respectively, of *System 39 The Rare Earth Elements, the Gmelin Handbuch der Anorganischen Chemie.* Both books contain the usual features which include English table of contents, preface and margin notes. In addition, book C5 has added a brief review in English at the beginning of each section.

Book C3 begins with a comprehensive review of the gaseous and solid phases in the rare earth fluoride systems. Information on the preparation, crystal data, chemical, thermodynamic, magnetic, electrical, and optical properties and applications of these compounds is presented. Comparative data are included for the rare earth fluoride oxides, fluoride hydroxides and fluoride nitrides. The alkali fluorometallates of the rare earths are also dealt with extensively since these compounds are candidates for several optical applications. Book C3 was published by Springer-Verlag in 1976, is 439 pages in length and costs DM 794(~$384.00).

Volume C5 treats the rare earth hydride chlorides, oxide chlorides, hydroxide chlorides, oxide hydroxide chlorides, chlorites, chlorates, perchlorates, chloride fluorides, oxide chloride fluorides, alkali chlorometallates, alkali oxide chlorides and alkali chloride fluorides. Emphasis has been placed on the preparation, crystallographic and thermodynamic properties of the oxide chlorides and the phase diagrams of the rare earth alkali chlorometallate systems. In addition to the material that is presented, this book serves the reader in showing how much information is not known about these systems. Published in 1977 by Springer-Verlag, Book C5 is 259 pages in length and costs DM 621 (~$300.00).

AIME FELLOWS

Dr. T. A. Henrie and Dr. C. J. McHargue have been named Fellows of the AIME (Amer. Inst. of Mining, Metallurgical and Petroleum Engineers) at the annual meeting held in Denver, Colorado, during February. Henrie has been active in rare earth metal preparation through electrowinning, while McHargue has studied the physical metallurgy of cerium.

Nd OPTICAL GAIN

R. R. Jacobs and W. F. Krupke have made the first observation of optical gain for trivalent rare earth molecular vapors using a neodymium chloride-aluminum chloride vapor complex [*Appl. Phys. Letters* **32,** 31-3 (1978)]. An optical gain of >.25%/cm was measured for the Nd^{3+}: $^4F_{3/2} \rightarrow {}^4I_{11/2}$ transition at 1.06 μm which corresponds to an energy density storage of approximately 35 J/l which lasts for more than 10 μsec. The gain signal amplitudes were dependent upon the optical excitation intensity, the degree of overlap between the pump and probe laser beams and the NdAlCl vapor density. Intracavity losses were caused by etching, impurities and schlieren effects. The authors feel that this type of laser system will find application as an amplifier media for fusion laser systems because of its large energy density storage, potential for high overall efficiency, emission wavelengths in the visible and near-infrared regions and capability for high average power operation through medium flow and relaxation of the stringent system constraints dictated by the nonlinear optical properties of most solids.

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K. A. Gschneidner, Jr. . . .Editor
Bernie Evans. . .Staff Writer

14th Rare Earth Research Conference

The 14th Rare Earth Research Conference will be held at the Conference Center on the North Dakota State University campus in Fargo June 25-28, 1979. Fargo is served by five airlines. Winnipeg, Canada and Minneapolis, Minnesota are only 45 minutes away by air with frequent flights making direct connections to other national and international airlines. Interstate Highway I-29 (North-South) and I-94 (East-West) as well as Amtrak provide easy access to Fargo, an agricultural and distribution center for the Upper Midwest.

The program will include the following major topics:

General and Analytical Chemistry, Solutions and Solvation, Biochemistry, Geochemistry, Spectroscopy, Metallurgy, Crystal Growth, Intermetallic Compounds, Phase Studies and Diagrams, Solid State Physics, X-ray Diffraction, Neutron Scattering, Magnetism, Thermal and Transport Properties, Surface and Interface Phenomena, Rare Earth Technology, Industrial Processes, Uses and Applications.

The first Rare Earth research prize to be awarded at rare earth research conferences will be made at this meeting. For more information see the article entitled "Rare Earth Prize" on page 1.

We hope to have in attendance the leading experts in rare earth science and technology from around the world. We hope to maintain the strong interdisciplinary character of the previous conferences and to have substantial representations from government, academic and industrial institutions.

To assist the Program Committee in detail planning, please complete and return before September 1, 1978, the preliminary information form provided below.

(DETACH)

14th Rare Earth Research Conference

North Dakota State University, Fargo, North Dakota, U.S.A. June 25-28, 1979

Please complete the following and send before September 1, 1978 to:

Dean John B. Gruber
College of Science and Mathematics
North Dakota State University
Fargo, North Dakota 58102 U.S.A.

This form is for information only and carries no final commitment.

PLAN TO ATTEND ☐ Yes ☐ No PLAN TO PRESENT PAPER ☐ Yes ☐ No

SPOUSE ATTENDING? ☐ Yes ☐ No TOTAL NO. IN YOUR PARTY _____

Special interest area(s). _____

_____

Name _____

Address _____

_____

Previous RE Conference Proceedings

ASM-AEC Symposium on Rare Earths, Chicago, Illinois, November, 1959.
The Rare Earths. F. H. Spedding and A. H. Daane, eds., John Wiley and Sons, Inc., New York (1961). Reprinted and available from R. E. Krieger Publishing Co., Inc., P. O. Box 542, Hungtington, NY 11743: $16.50.

First Rare Earth Research Conference, Lake Arrowhead, California, October, 1960.
Rare Earth Research, E. V. Kleber, ed., Macmillan Co., 866 Third Avenue, New York, NY 10022. $10.95.

Second Rare Earth Research Conference, Glenwood Springs, Colorado, September 24-27, 1961.
Rare Earth Research, J. F. Nachman, C. E. Lundin, eds., Gordon and Breach Science Publishers, Inc., 1 Park Avenue, New York, NY 10016. $44.50.

Third Rare Earth Research Conference, Clearwater, Florida, April 21-24, 1963.
Rare Earth Research II, K. S. Vorres, ed., Gordon and Breach Science Publishers, Inc., 1 Park Avenue, New York, NY 10016. $76.00.

Fourth Rare Earth Research Conference, Phoenix, Arizona, April 22-25, 1964.
Rare Earth Research III. L. Eyring, ed., Gordon and Breach Science Publishers, Inc., 1 Park Avenue, New York, NY 10016. $77.00.

*Proceedings of the 5th Rare Earth Research Conference, Ames, Iowa, August 30-September 1, 1965.**

Book 1 (Spectra)	AD-627 221 [also CONF-650804-(Bk. 1)]
Book 2 (Solid State)	AD-627 222 [also CONF-650804-(Bk. 2)]
Book 3 (Chemistry)	AD-627 223 [also CONF-650804-(Bk. 3)]
Book 4 (Solid State)	AD-627 224 [also CONF-650804-(Bk. 4)]
Book 5 (Metallurgy)	AD-627 225 [also CONF-650804-(Bk. 5)]
Book 6 (Solid State)	AD-627 226 [also CONF-650804-(Bk. 6)]

Book 1 $6.75. Book 2, $5.50. Book 3, $6.00. Book 4, $5.00. Book 5, $6.00. Book 6, $4.50.

Symposium co-sponsored by the Division of Inorganic Chemistry and The Division of Nuclear Chemistry and Technology, 152nd ACS meeting. New York, New York, September 13-14, 1966.
Advances in Chemistry Series No. 71 Lanthanide/Actinide Chemistry. P. R. Fields and T. Moeller, symposium chairmen. Available from special issue sales. American Chemical Society, 1155 16th Street N. W. Washington, DC 20036 USA $16.50.

*Proceedings of the 6th Rare Earth Research Conference, Gatlinburg, Tennessee, May 3-5, 1967. CONF-670501.** $18.75.

Proceedings of the 7th Rare Earth Research Conference, Coronado, California, October 28-30, 1968. Sessions A-H CONF-681020-(Vol. 1) and Session I-M, CONF-681020-(Vol. 2)*. $21.25 for both volumes.

French International Rare Earth Conference, May 5-10, 1969. Paris and Grenoble, France
Les Elements des Terres Rares, Tome I and Tome II, Bureau 3A-Service de Presse, Centre National de la Recherche Scientifique. 15 Quai Anatole France, Paris 7e. France. Tome I-price unknown, Tome II-107.50 F.

Proceedings of the 8th Rare Earth Research Conference, Reno, Nevada, April 19-22, 1970, available from Dr. R. Lindstrom, Reno Metallurgy Research Center. U.S. Bureau of Mines, Reno, NV, 89505, USA, $17.00.

Conference on Rare Earths and Actinides. University of Durham, Durham City, England, July 5-7, 1971.
Conference Digest No. 3, Rare Earths and Actinides, Durham 1971, Institute of Physics, London, England (1971). Available from the Institute of Physics, Distribution Center, Blackhorse Road, Letchworth, Herts SG6 1HN, England. £7.50 (except £3.75 for members of the Institute of Physics).

Proceedings of the 9th Rare Earth Research Conference, Blacksburg, Virginia, October 10-14, 1971, available from Dr. Larry Taylor, Department of Chemistry, Virginia Polytechnic Institute and State University, Blacksburg, VA 24061. USA. $20.00.

NATO Advanced Study Institute on Analysis and Application of Rare Earth Materials, Kjeller, Norway. August 23-29, 1972.
Analysis and Application of Rare Earth Materials, O. B. Michelsen, ed., Universitetsforlaget, Oslo, Norway (1973), available from Universitetsforlaget, P. O. Box 307, Blindern, Oslo 3, Norway or from Universitetsforlaget, P. O. Box 142, Boston, MA 02113. $28.00.

Proceedings of the 10th Rare Earth Research Conference, Carefree, Arizona, April 30-May 3, 1973. CONF-730402-(P 1-2)* $27.20.

Seventh Russian Conference on Rare Earth Metals, Moscow, USSR. Sept. 12-17 (1972). *Rare Earth Metals, Alloys and Compounds* [*Redkozemelnye Metally Splavy i Soedineniya*] (Izdatel'stvo Nauk, Moscow, 1973) 355 pp. Cost is 1R, 81K (~ $2.00 U.S.) [14 papers in English, 5 in French and 67 in Russian]. Suggest contacting a book store dealing with Soviet publications.

Proceedings of the 11th Rare Earth Research Conference, Traverse City, Michigan, Oct. 7-10, 1974, available from Dr. Harry A. Eick, Department of Chemistry, Michigan State University, East Lansing, MI 48824, U.S.A., $30.00.

Proceedings of the 12th Rare Earth Research Conference, Vail, Colorado, July 18-22, 1976, available from Dr. C. E. Lundin, Denver Research Institute, University of Denver, Denver, CO 80210. $40.00.

Thirteenth Rare Earth Research Conference, Oglebay Park, West Virginia, October, 1977. *The Rare Earths in Modern Science and Technology,* G. J. McCarthy and J. J. Rhyne, eds., Plenum Publishing Corp., New York (to be published in 1978).

* Available from the National Technical Information Service, Springfield, VA 22151, USA.

Garnet Preparation and Properties Reviewed

Citing many of the advantages of using magnetic domain devices rather than semiconductors for computer logic and memory, V. N. Dudorov, V. V. Randoshkin and R. V. Telesnin have reviewed the synthesis and physical properties of single crystal films of rare earth iron garnets [*Usp. Fiz. Nauk* **122,** 253-93 (1977); Eng. Transl.-*Sov. Phys. Usp.* **20,** 505-27 (1977)]. The requirements and problems encountered in liquid phase epitaxial growth of single crystal garnet films are discussed and methods of quality control during and after production are noted. Basic properties of the films including optical absorption, Faraday rotation, characteristic length, saturation magnetization, domain wall energy, coercive force, magnetic anisotropy, quality factor, exchange constant, ferromagnetic resonance and mobility of domain walls are discussed along with the different methods of measurement of these properties. Finally, the reproducibility and temperature stability of the principal magnetic parameters are examined. The authors note that higher domain wall velocities and a wider temperature range of stability of garnet properties are areas where progress can be made with additional research. 437 references were cited.

RE-O BONDS

C. Linares, A. Louat and M. Blanchard have undertaken a systematic study of the fluorescence spectra of the isostructural compounds of gadolinium, yttrium and lutetium phosphates, arsenates and vanadates doped with trivalent europium, to gain an insight to the character of rare earth-oxygen bonding [*Structure and Bonding* **33,** 179-207 (1977)]. From the experimental data, crystal field parameters and intrinsic parameters relative to europium-oxygen bonding are determined. Various theories including the point charge model, superposition model, angular overlap model, Jørgensen model and Kibler's model are compared and evaluated. The authors feel that additional optical studies like this one can reveal much useful information concerning rare earth-ligand bonding.

1st Operational Magnetic Bubble Lattice Device

The first magnetic bubble lattice device which contains all the elements needed to read, write and store information in a hexagonal array of magnetic bubbles has been developed by researchers at IBM's San Jose, California Research Laboratory [*Metal Progress* **113,** 3 (March 1978)]. Yttrium iron garnet film which is 0.4 mm (1/64 in.) long is used to store information at a density of 8000 bits per square millimeter (5 million per square inch). This density is four times that of currently available devices and there is potential to go as high as hundreds of thousands of bits per square millimeter. "Zeros" and "ones" are coded into the magnetic structure of the domain wall surrounding each bubble. Information is read by detecting the motion of the bubble along a column. If it moves along the line of a column a "zero" is read and if it moves at a 30° angle from the column a "one" is read.

METAMAGNETISM

Physical properties of metamagnets are the subject of a review completed recently by E. Stryjewski and N. Giorano [*Advances in Phys.* **26,** 487-650 (1977)]. Metamagnets are defined as antiferromagnets which, upon application of a magnetic field, undergo first order magnetic phase transitions to a state with a relatively large magnetic moment. This article is further restricted to those materials which undergo a simple reversal in spin direction. Current theories on metamagnetism are briefly reviewed with a special section on demagnetizing effects. Experimental properties are discussed for two sublattice systems ($DyPO_4$, DySb, $TbPO_4$, $HoPO_4$), four sublattice systems ($TbAlO_3$, $DyAlO_3$, CeBi, CeSb, $DyVO_4$, $DyAsO_4$, EuSe), linear chain systems (Eu_3O_4) and garnets ($Dy_3Al_5O_{12}$, $Tb_3Al_5O_{12}$, $Ho_3Al_5O_{12}$). Tricritical and critical behavior are also discussed for $Dy_3Al_5O_{12}$ and $DyPO_4$. In addition, Appendix I contains information on miscellaneous metamagnetic materials, many of which contain rare earths. Appendix II lists in tabular form the bulk magnetic properties of the metamagnetic materials discussed in the review.

CONTRIBUTORS

Nine companies renewed their support of the Center and two companies became first year contributors in the final quarter of the fiscal year 1978 to bring the total number of companies to 46. For the second year in a row, a new record has been set as this year's 46 surpasses last year's record of 41. Contributors for this quarter are listed below (the number in parentheses is the number of years the company has supported RIC).

Allied Chemical Corporation, U.S.A. (6),
Bose Corporation, U.S.A. (1),
General Electric Co., Quartz and Chemical Products Dept., U.S.A. (3),
GTE Laboratories, Inc. U.S.A. (6),
Industrial Minera Mexico, S.A., Mexico (4),
Malaysian Rare Earth Corp. Sdn. Bhd., Malaysia (1),
A/S Megon, Norway (8),
Mischmetal and Flints Private, Ltd., India (2),
Nuclemon-Nuclebras de Monazita e Associados Ltda., Brazil, (6),
Union Carbide Corporation, Linde Division, U.S.A. (2)

RE-Fe Sound Transducer

A low-frequency, resonant, longitudinally vibrating piston-type underwater sound transducer has been used by S. W. Meeks and R. W. Timme to compare the relative merits of $Tb_{0.27}Dy_{0.73}Fe_2$ and the currently used PZT-4 ceramic [*J. Acoust. Soc. Am.* **62,** 1158-64 (1977)]. Unfortunately, they conclude that the rare earth-iron alloys pose no threat to the ceramics but that a complimentary role as a low-frequency high-power projector is possible. The rare earth-iron alloy had better transmitting voltage responses at low frequencies, but the ceramic transducer gave better transmitting current responses and had higher free-field voltage sensitivities. The biggest problems in this experiment for the rare earth-iron alloy were the eddy current and hysteresis losses which dissipated almost one-half of the input power. Additionally, the large magnetic fields which are needed might also saturate the magnetic return path. The authors were successful in developing a theoretical model to explain these effects.

QH21A

The need for high strength magnesium casting alloy with greater temperature stability than currently available alloys has lead to the development of a magnesium-silver-neodymium-thorium-zirconium alloy designated QH21A according to W. H. Unsworth [*Light Metal Age* **35** [5/6] 14-6 (1977)]. The desired properties result from the ability of silver and neodymium to form a stable hardening precipitate. This action is further enhanced by the addition of thorium, although for optimum mechanical properties and acceptable casting characteristics the neodymium-thorium ratio must be tightly controlled. The new alloy is readily weldable with reasonable freedom from microshrinkage and its properties are not influenced by section thickness. Temperature stability is such that operating temperatures can be increased up to 120° F (50° C) over previously used alloys and the strain fracture toughness is 50% higher. In fact its high temperature yield strength at 480° F (250° C) allows QH21A to compete effectively even against high strength aluminum-base alloys. With these developments the author notes that magnesium casting alloys should satisfy the requirements of aerospace designers for the forseeable future.

Univ. New South Wales
(continued from page 1)

romagnets and thus aid the continuing struggle for purer rare earth materials.

Current research on gadolinium concerns full characterization of the magnetic aftereffect and examination of low-field hysteresis. The latter studies are proving to be very productive and should result in a better understanding of the fundamental cause of magnetic hysteresis. Also, the current critical exponent analysis of the low-field susceptibility measurements will result in a value for the critical exponent γ obtained from truly field-independent data. T. J. McKenna is applying these well-established techniques to order-order transitions, specifically on the rare earths terbium and dysprosium. The preliminary thermal modulation results on terbium, which has both ferromagnetic and antiferromagnetic transition temperatures separated by only 8 K. are quite interesting.

$(NC_4H_4N)[Yb(C_5H_5)_3]_2$

μ-Pyrazine-bis [tris (cyclopentadienide) ytterbium (III)] has the distinction of being the first pyrazine-bridged complex of an *f*-transition element to be prepared according to E. C. Baker and K. N. Raymond [*Inorg. Chemistry* **16**, 2710-4 (1977)]. The complex is remarkably thermally stable and sublimes at 75° C, which places it among the more volatile of all the lanthanide compounds. Structurally the complex resembles tris-cyclopentadienide complexes of the actinide series. Simple Curie-Weiss behavior was exhibited by the magnetic susceptibility and no evidence was found of any magnetic interaction between the two metal centers or reduction of magnetic moment due to *f*-orbital covalency. This and the consistancy of the bonding parameters suggest to the authors that an ionic formulation of the bonding would be more appropriate in this case in contrast to suggestions of covalent bonding made for related compounds.

REers ON THE MOVE

Molycorp has announced the addition of H. H. Cornell and G. A. Ratz to their metallurgical service group. Both Cornell, formerly operations and product development coordinator at Molycorp's Washington, PA, ferroalloys production unit, and Ratz, formerly senior research engineer at U.S. Steel's Technical Center at Monroeville, will work out of Molycorp's Pittsburgh offices at Gateway Center, concentrating on the increasing variety of steelmaking and foundry needs for rare earth additions.

Linear Actuators
(continued from page 1)

times less than an alnico magnet. This reduction in weight means an improved (decreased) response time for the linear actuator. The Sm-Co permanent magnet used in these experiments was actually a series of rectangular blocks arranged to form a radially oriented ring. The author feels as soon as the technology is developed to produce one piece radially oriented Sm-Co magnets, the cost and performance advantages will become even more attractive.

RE's in the News

REs Aid Crystal Studies

Rare earths in the form of X-ray intensification screens have been incorporated into diffraction cassettes for Laue and Precession photography by researchers at the Polaroid Corporation. The rare earth screens are twice as sensitive as the currently used screens which allow for a 50% reduction in exposure time.

EIO's WITH Sm-Co

Researchers at Varian Canada have developed an extended interaction oscillator (EIO) which uses samarium cobalt permanent magnets. The samarium cobalt magnet reduces the EIO's weight by ~ 67% and physical size by around 33%. Applications could include airborne and missile radar systems where reliability, weight and size must be optimized.

W. G. Wilson, formerly manager of market development of ferroalloys at Molycorp, has taken a position with American Metallurgical Products Company as managing director of rare earth activities.

Rare-Earth Information Center
Energy and Mineral Resources Research Institute
Iowa State University
Ames, Iowa 50011

RARE-EARTH INFORMATION CENTER NEWS

ENERGY AND MINERAL RESOURCES RESEARCH INSTITUTE
IOWA STATE UNIVERSITY / AMES, IOWA

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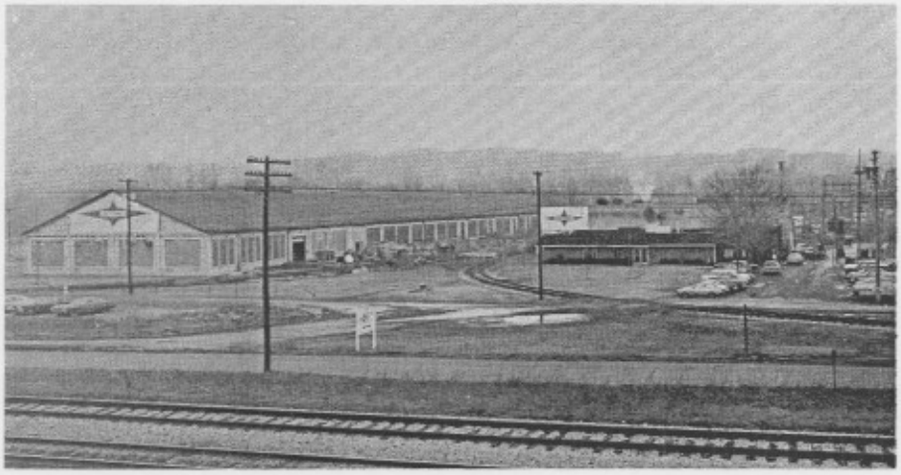
Who is .... 'The Rare Earth Industry'?



Reactive Metals & Alloys Corporation

Reactive Metals & Alloys Corporation (REMACOR) was formed in March of 1975 and has grown dramatically during the past three years. Today REMACOR employs 150 people and occupies 210,000 square feet of manufacturing and office facilities on a 25 acre industrial site in West Pittsburg, Pennsylvania. West Pittsburg is located approximately 40 miles north of Pittsburgh.

REMACOR manufactures cerium mischmetal by fused salt electrolysis and presently has a 4 million pound capacity plant which is the world's largest. In addition, REMACOR also manufactures various grades of rare earth silicide, single ladle desulfurizing compounds, and other specialty alloys for the iron and steel industries.

The rapid growth of REMACOR is attributed to a close technical relationship with users in developing practical and economical methods in the applications of their products. Three patents have resulted and a fourth has been applied for in addition to the publication of numerous technical papers on the use of rare earths in steel. The most significant patents are two that were granted for the method and apparatus used in adding mischmetal to molten steel by plunging a reactive mixture of magnesium and mischmetal. This technique is presently being used by steelmakers worldwide to treat molten steel in the ladle with mischmetal. REMACOR's activity in the steel industry over the past three years is actually a continuation of an extensive and aggressive marketing effort that started in early 1973. Today, rare earths are becoming more important in the new microalloying technology which is a significant tool used to obtain the physical properties that are necessary for today's applications of high strength low alloy steels and other critical grades of steel.

Recently REMACOR began manufacturing special electrolytic mischmetal alloys that are being used by the magnet industry in the production of mischmetal-cobalt magnets. Further research and development of other rare earth products are also being planned.

A brochure and catalog are available by writing to REMACOR, P.O. Box 366, West Pittsburg, PA 16160. Telephone 412-535-4357. TWX 510-461-0208.

EDITORS NOTE:

This is one of a continuing series of features on rare earth industry. The information contained herein was supplied by the company featured and its publication should not be construed to constitute an endorsement by RIC or Iowa State University of the products or services offered by the company.

FISCAL YEAR 1979

The new fiscal year is upon us and judging from the response so far the economic picture for the rare earth industry looks as bright as a rare earth phosphor! To date twenty companies have renewed their support of RIC and over 60% were able to increase this year's contribution. First quarter contributors are listed below. The number in parentheses is the number of years the company has supported the Center.

American Metallurgical Products Co., U.S.A. (10)
Atomergic Chemetals Corp., U.S.A. (7)
BBC Brown, Boveri & Co., Ltd., Switzerland (7)
Denison Mines, Ltd., Canada (7)
Ferro Corp., Transelco Div. (formerly Transelco), U.S.A. (3)
Th. Goldschmidt AG, Germany (10)
W.R. Grace, Davison Chemical Div., U.S.A. (11)
Hitachi Magnetics Corp., U.S.A. (5)
Indian Rare Earths, Ltd., India (10)
Inland Motor Div., Kollmorgen Corp., U.S.A. (3)
Kolon Trading Co., U.S.A. (6)
Leico Industries, Inc., U.S.A. (10)

(continued on page 2)

13th Proceedings Published

The proceedings of the 13th Rare Earth Research Conference held at Oglebay Park, West Virginia in October 1977 are now available as a book entitled *The Rare Earths in Modern Science and Technology,* edited by G. J. McCarthy and J. J. Rhyne. The book, published in 1978, is 629 pages in length and costs $49.50. Copies may be obtained by writing to Customer Service, Plenum Press, 227 West 17th Street, New York, NY 10011. Prepaid orders from individuals receive a ten percent discount.

Fiscal Year
(continued from page 1)

Mitsubishi Chemical Industries, Ltd., Japan (6)
Reactor Experiments, Inc., U.S.A. (9)
Rhone-Poulenc-Chimie Fine, France (9)
Ronson Metals Corp., U.S.A. (11)
V/O Techsnabexport, U.S.S.R. (2)
Treibacher Chemische Werke AG, Austria (7)
United States Radium Corp., U.S.A. (9)
Wako Bussan Co., Ltd., Japan (10)

Additionally, five companies receive special recognition this year for their role in the success of the Rare-Earth Information Center. With this year's contribution they qualify for the RIC Honor Roll which signifies 10 years of support of RIC.

Finally, we would like to correct a rare earthly goof in the "Contributors" story in the June 1978 issue of the *RIC News.* The story stated that eleven companies contributed during fourth quarter of fiscal year 1978, however, as most of our sharp readers noticed, only ten companies were listed. Unfortunately, GTE Sylvania Inc. was inadvertently left out of the list. We apologize for this omission and hope that in the future we will be perfect.

LETTER

To the Editor:

It has come to our attention that in current chemical literature element symbols are misused for the abbreviation of organic radicals. In the June edition of *Angewandte Chemie* **90,** 483, 490 (1978) the chemical symbol Pr is not used as the legitimate symbol for element 59, praseodymium, but as the symbol for the organic group propyl, C_3H_7. I have filed a sharp protest with the editors of *Angewante Chemie.* After asking one of the authors in question, it turns out that the IUPAC nomenclature commission has allowed the use of the symbol Pr for propyl. Another example of the misuse of element symbols is Ac. The symbol for element 89, actinium, is frequently misused for the acetyl group or the acetate ion.

May I therefore suggest that a formal protest against this practice be filed with the International Union. In this protest, it is requested that the use of element symbols should be restricted to denominate these elements and nothing else.

It is further requested that the following sentence be added to the general rules for chemical nomenclature: "Element symbols appearing in the Periodic Table of Elements should be reserved solely for the elements they represent. They should never be used as abbreviations for any radicals, groups or ligands."

Sincerely,
Fritz Weigel
Inst. Anorganische Chemie
Universität München
Meiserstrasse 1
München 2,
West Germany

EDITORS NOTE: Readers interested in discussing Dr. Weigel's proposal are encouraged to contact him directly at the above address. Dr. Weigel has suggested that this be discussed at the 14th Rare Earth Research Conference. Those interested in the latter suggestion should address their thoughts or comments to the Conference Chairman, Dr. J.B. Gruber, North Dakota State University, Fargo, ND 58102, U.S.A.

Source Compilation

Sources of single crystals in the United Kingdom and Scandinavia have been compiled and published in March of this year by B. M. R. Wanklyn. Sources of single crystals of a plethora of rare earth materials including rare earth metals, alloys and intermetallic compounds with Al, Fe, Co, Ni, Ag, Ca, oxides, chlorides, fluorides, garnets, aluminates, titanates, vanadates, molybdates, ferrites, phosphates, borates, silicates, germanates, stannates and tungstates are listed.

Copies may be obtained by writing to Mrs. B. M. R. Wanklyn, Clarendon Laboratory, Parks Road, Oxford OX1 3PU, United Kingdom. Scientists outside of the United Kingdom should include International Postal Reply Coupons in the amount of £0.80 for surface mail or a banker's draft in the amount of £3 drawn in sterling for airmail postage.

Durham 1977 Proceedings

The Proceedings of the International Conference on Rare Earths and Actinides held in Durham, England, July 4-6, 1977 are now available as a book entitled *Rare Earths and Actinides 1977, Institute of Physics Conference Series Number 37.* Edited by W.D. Corner and B.K. Tanner and published by the Institute of Physics, London, in 1978 the book is 346 pages in length and costs $42.00 in North America, £22.00 in all other countries. To obtain a copy in the USA, Canada or Mexico write to: American Institute of Physics, Dept. B/N, 335 East 45 Street, New York, NY 10017, U.S.A. All other countries should contact the Institute of Physics, The Distribution Center, Blackhorse Road, Letchworth, Herts SG6 1HN, England.

The book contains ten invited and forty eight contributed papers on material preparation, structural and elastic properties, excitations and spin waves, band structure and Fermi surfaces, crystal and hyperfine fields and magnetic properties of the rare earths and actinides. Another chapter was devoted entirely to rare earth intermetallics and several papers discussed economic aspects and applications of rare earth materials. Only eight of the 58 papers deal exclusively with actinides.

L. F. Bates Dies

RIC has received word of the death of Professor L. F. Bates on January 20 of this year at the age of 80 following a short illness. Professor Bates, an Emeritus Professor of Physics at Nottingham University is best known for his work on permanent magnetic materials and his study of the magneto-thermal effects accompanying magnetization which included work on several of the rare earths during the late 1950's and early 1960's before his retirement in 1964.

RE's in the News

Magnetic Bubbles

Researchers at the IBM Thomas J. Watson Research Center, Yorktown Heights, NY, seem to have no respect for words like 'small' and 'dense' when it comes to magnetic bubbles in garnets. They have discovered stable magnetic bubbles with 0.4 μm diameters which compares to currently available diameters in the 3 to 5 μm range. If these new bubbles can be developed bubble memory storage density would jump from 0.47×10^6 bits/cm^2 to 16×10^6 bits/cm^2.

More Magnetic Bubbles

While IBM researchers have been working on 'small' and 'dense', researchers at Philips Research Laboratories, Eindhoven, The Netherlands, have been working on 'fast'. By incorporating a layer which allows for a magnetic field parallel to the bubble layer, bubble speeds of 100 m/sec have been demonstrated.

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K. A. Gschneidner, Jr.. . .Editor
Bernie Evans. . .Staff Writer

COEXISTANCE?

A political dispute? No, a question that has puzzled many researchers concerning superconductivity and magnetic order. S. Roth has attempted to shed some light on the subject with a review of the experimental work on materials which show evidence of the coexistence of superconductivity and long range magnetic order [*Appl. Phys.* **15,** 1-11 (1978)]. Among the candidates for coexistance are intra-rare earth alloys, Laves phases between rare earths and ruthenium, osmium and aluminum, Chevrel phases and even a few stoichiometric compounds. Besides discussing critical temperature and fields, the author examines experimental techniques including magnetic susceptibility, specific heat, Mössbauer effect and neutron diffraction. Roth concludes that most of the materials being studied should be called superconducting spin glasses rather than ferromagnetic superconductors. Furthermore, it is possible for magnetic order to coexist with superconductivity when the correlation length associated with magnetic order is larger than the superconductive coherence length.

3rd RE-Co WORKSHOP

The *Proceedings of the Third International Workshop on Rare Earth-Cobalt Permanent Magnets and Their Applications,* held June 27-30, 1978 at San Diego, California and edited by K. J. Strnat, are now available as a 400 page paperbound volume for $25.00. Thirty articles describe various applications of samarium cobalt base alloys including electric motors and actuators, generators, magnetic bearings, microwave tubes, coaxial couplings, line printers, watches and applications in modern medicine. New materials and processes, raw materials availability and economic questions are discussed.

Likewise, the *Proceedings of the Second International Symposium on Magnetic Anisotropy and Coercivity in Rare Earth-Transition Metal Alloys,* held July 1, 1978 at San Diego and also edited by K. J. Strnat, are available as a 175 page paperbound volume for $10.00. As the title states the nine articles deal with the

(continued on page 4)

Magnetic Heat Pumps Revisited

On page 3 in the December 1976 issue of the *RIC News* we made note of a magnetic heat pump developed by G. V. Brown which used gadolinium as the refrigerant. Now S. S. Rosenblum, W. A. Steyert and W. P. Pratt, Jr. have also constructed a continuous magnetic refrigerator operating near room temperature [LA-6581 (May 1977)] and with the help of J. A. Barclay, developed a continuous demagnetization refrigerator that operates near 2 K [*Cryogenics* **17,** 689-93 (December 1977)]. The room temperature refrigerant was gadolinium while the low temperature refrigerant was $Gd_2(SO_4)_3 \cdot 8H_2O$. In addition, Er_2O_3, Dy_2O_3, $Gd_3Al_5O_{12}$, $Dy_2Ti_2O_7$, $DyPO_4$, $Gd(OH)_3$ and $Gd(PO_3)_3$ were examined for suitability as low temperature refrigerants.

A Sterling-type cycle is used in which the magnetically ordered refrigerant is exposed to the low temperature side, (*via* a liquid heat-exchanger), absorbs heat and disorders. The refrigerant then rotates to the high temperature side and in the presence of a magnetic field orders magnetically and gives off heat.

The authors feel that these prototypes clearly demonstrate the feasibility of this type of refrigeration although improvements can still be made in materials selection and fabrication. Possible applications include providing a suitable environment for superconducting devices.

NEW RE JEWELRY

Yttrium aluminum garnet (YAG) has long been accepted as a setting for rings, substituting for the more expensive diamond. Now samarium, in the form of samarium cobalt permanent magnets, has made a hit as the latest thing in jewelry, the magnetic earring. The earrings avoid risks of infection, allergic reaction and tearing often associated with pierced ears. There is some question as to how the magnets, which weigh .001 pound per set, will affect such medical devices as hearing aides, artificial pumps and pacemakers which also use magnets. At any rate, if the demand for the earrings continue to grow, the production of the samarium cobalt magnets will have to double to meet the demand; good news to the rare earth industry.

Electronic Structure of the Heavy Rare Earths

The Electronic Structure of Rare Earth Metals and Alloys—The Magnetic Heavy Rare Earths is the title of a new book written by B. Coqblin. Published by Academic Press in 1977, the book is 656 pages in length and costs $57.75. Coqblin concentrates on the heavy lanthanides, gadolinium, terbium, dysprosium, holmium, erbium and thulium. They are considered 'normal' lanthanides in that they have a valence of 3 which does not vary under pressure. A brief overview of the elementary properties of the lanthanides is given. The the experimental observations on the magnetic structures are presented and molecular field theory and spin wave theory for magnetic ordering are discussed. Experimental evidence of spin waves is shown. The last half of the book deals with variation of magnetic periodicity, superzones, magnetoelastic effects, magnetic structure transitions, magnetic resonance, magnon-phonon interaction, band structure effects and transport properties. This book should prove to be an excellent reference work for solid state physicists as well as any other field that requires knowledge of the electronics of metals.

RE-Co Workshop
(continued from page 3)

magnetic anisotropy and/or coercivity of samarium-cobalt base permanent magnetic alloys.

Both of these books may be obtained by writing to the University of Dayton, School of Engineering, Attn.: Mrs. A. Fox, KL365, Dayton, OH 45469. There are still copies of the *Proceedings of the Second International Workshop on Rare Earth—Cobalt Permanent Magnets and Their Applications,* K. J. Strnat, ed., June 1976, available. It is 396 pages long, costs $25.00 and can also be obtained by writing to the Dayton address.

One of the papers presented during the 3rd Workshop entitled "Availability of Rare Earths for the Rare Earth Cobalt Permanent Magnets Market," but not included in the Proceedings may be obtained by writing to J.-P. Fort, Rhodia Inc., Chemicals Division, P.O. Box 125, Monmouth Junction, NJ 08852, U.S.A.

Molycorp Expansion

Citing growing demands for samarium for use in permanent magnets in solid armature motors, self holding jewelry, and data printout equipment and for gadolinium for use in magnetic bubble memory systems in computers, Molycorp has announced a multimillion dollar expansion of their Mountain Pass, California bastnasite processing facilities. Six new solvent extraction circuits are to be constructed.

Analogous to RE's

L. A. Boatner and M. M. Abraham have reviewed the available experimental data and techniques involved in measuring the electron paramagnetic resonance (EPR) from the actinide elements [*Rep. Prog. Phys.* **41,** 87-155 (1978)]. This review should prove interesting to those f-shell enthusiasts in our readership since there is an emphasis on comparing the results obtained for the actinides with those obtained for the rare earths. EPR theory is discussed with respect to crystal field effects, hyperfine interactions and 'pseudonuclear' g factors.

CADANG-CADANG?!!?

This article's title might arouse several questions like "What is cadang-cadang?" and "What has it got to do with the rare earths?" To answer the first question, cadang-cadang is a disease that attacks coconut trees reducing their productivity and eventually killing them. To answer the second question, nothing, we hope. J. R. Velasco, L. E. Domingo, Z. N. Sierra and F. F. Coronado have undertaken a study to determine if the rare earths have any connection to cadang-cadang [*Philippine J. of Coconut Studies* **11,** [2] 1-6 (1977)]. Researchers suspect the disease to be caused either by a virus or by a toxic concentration of a normally innocuous element. Although the present research did indicate a higher concentration of rare earths in the cadang-cadang affected groves the authors noted many procedural and experimental difficulties which rendered their results inconclusive.

GIANT Magnetic Hardness

Materials which exhibit an extremely large magnetic hardness as an intrinsic solid state property is the subject of a review by H. Oestereicher [*Appl. Phys.* **15,** 341-54 (1978)].These materials differ from other magnetically hard materials in that the hardness is not due to the presence of fine particles or precipitate phases, but rather, to exchange interaction fluctuations. Characteristics of these materials include partly randomized crystallography and high magnetic anisotropy. Pseudobinary compounds of the rare earths with iron, aluminum, cobalt, nickel and copper with the stoichiometries RM_2, RM_3, R_2M_{17} and RM_5 are representative of this type of material. Likewise are the compounds Dy_3Al_2, TbGa, $SmCo_3B_2$ and $ErCo_3B_2$ and amorphous materials such as YFe_2, $SmFe_2$, $TbFe_2$ and $DyFe_2$. The effect on coercivity of concentration, crystal field effects, temperature and time are examined. The author suggests measurement of the intrinsic magnetic hardness as a probe to determine the suitability of technologically interesting materials for permanent magnet applications.

Rare-Earth Information Center
Energy and Mineral Resources Research Institute
Iowa State University
Ames, Iowa 50011

RARE-EARTH INFORMATION CENTER NEWS

ENERGY AND MINERAL RESOURCES RESEARCH INSTITUTE
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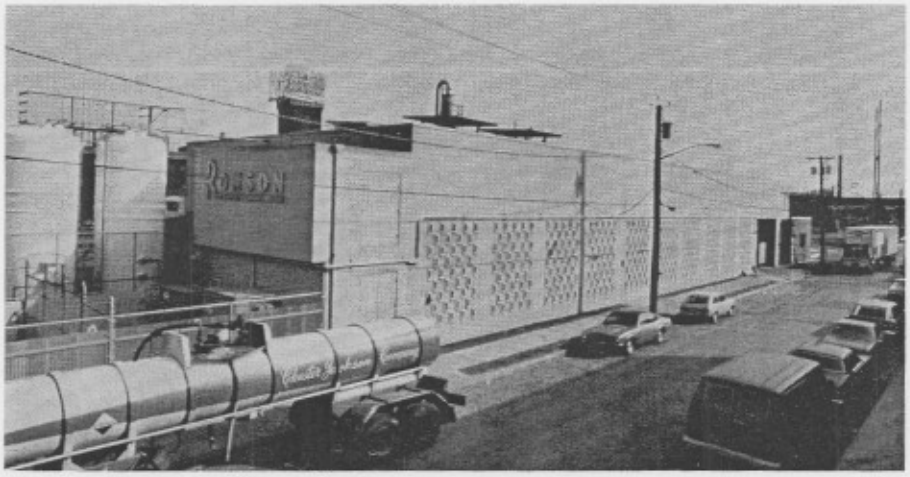
Volume XIII | December 1, 1978 | No. 4

Who is. . .'The Rare Earth Industry'?



New Plant Expansion at Ronson Metals

Ronson Metals Corporation

Ronson Metals Corporation of Newark, New Jersey, doubled its capacity for production of mischmetal during 1977. Throughout the year, demand by the steel industry for mischmetal (mixed rare earth metals) was exceptionally strong, as a result of which sales increased by substantially more than 100% over 1976. 1978 has seen continued growth in demand for mischmetal and sales of Ronson Metals Corporation for the whole year will set new records.

The versatility of mischmetal treatments in the production of nodular iron is demonstrated by its use in pressurized vessels, in open ladles, in plunging devices, in the Fischer Process, as well as in other ways. Mischmetal also makes a contribution towards minimizing in-plant pollution problems because of its non-smoking characteristic. Many foundries are raising the level of their mischmetal additions in order to enhance the recovery of magnesium, increase nodular count and decrease smoke levels.

Ronson Metals Corporation has been active in the application of the rare earth metals in alloys with cobalt for production of powerful permanent magnets. The role of mischmetal in this field is likely to increase at an accelerated rate as demand for these new magnets grows.

In addition to being one of the world's oldest and largest producers of mischmetal, Ronson Metals is one of the leading producers of cigarette lighters and welding igniter flints and other specialty pyrophoric and sparking metal products based on mischmetal-rich iron alloys.

Ronson Metals holds a variety of patents associated with the preparation and production of cerium and mischmetal alloys, thorium vacuum tube getters, metallurgical additives, sparking metal processes and products, extruded rare earth alloy products and abrasive evaluation equipment. A direct result of

(continued on page 4)

Financial Support. . .

. . .for the Center has matched last year's record-setting pace as ten companies renewed their support of RIC during the second quarter to bring the total number of companies to thirty. Contributors are listed below (the number in parentheses is the number of years the company has supported RIC).

Cerac, Inc., U.S.A. (3)
Eastman Kodak Company, U.S.A. (2)
Foote Mineral Company, U.S.A. (7)
Metalurgica Corona Ltda., Brazil (3)
Mischmetal and Flints Private Limited, India (3)
Molycorp, Inc., U.S.A. (11)
Rare Earth Products Limited, Great Britain (7)
Reactive Metals & Alloys Corporation, U.S.A. (3)
Santoku Metal Industry Co., Ltd., Japan (9)
Shin-Etsu Chemical Co., Ltd., Japan (9)

CEF Conference

Tentative plans have been made for an International Conference on Crystalline Electric Field and Structural Effects in *f*-Electron Systems to be held November 1979 in Philadelphia, PA, U.S.A. The precise time and location for the Conference will be announced later. The program is expected to include the following topics: crystal field excitations and lifetimes; exchange and quadrupolar interactions; cooperative phenomena, structural and magnetic transitions, surface magnetism; magnetoelastic and anisotropic effects; and influence of crystal field split ions on other properties. For more information and/or to suggest other topics write to:

Dr. J. E. Crow
Physics Department
Temple University
Philadelphia, PA 19122

EUROPE—1978

Garching-Grenoble-Zurich

Late last summer Grenoble, France and environs were for a few weeks the glittering Camelot of the condensed phase scientific world by hosting three major conferences: the 15th Low-Temperature Conference (LT-15), the Conference on the Electronic Structure of the Actinides, and the Colloquium on the Physics of Metallic Rare Earths. Although the editor only attended the last conference, many scientists attended two of the three and a few attended all of them.

The International Colloquium was held in a small village resort and ski town of St. Pierre de Chartreuse which is located in the French Alps about an hour's drive from Grenoble. The rainy weather kept the attendance in the oral and poster presentations probably higher than one might expect considering the beautiful and scenic surroundings. The French were excellent hosts and kept everyone well (perhaps too well) fed—the quantity was abundant and the quality was superb.

There were over 220 participants at the Conference from 22 countries, which included scientists from almost all of the Western European countries (12), Australia, Brazil, Bulgaria, Canada, Israel, Japan, Peoples Republic of China, Poland, U.S.A., and U.S.S.R. The Conference was divided into nine oral presentation sessions (two each day except Wednesday when there were three) and four poster sessions which were available to the participants all day. Each oral session began with two or three invited papers, (except the session on "Technical Applications" which consisted entirely of five invited talks) and these were followed by contributed papers. There were a total of 22 invited talks, 40 contributed oral papers, ~ 77 poster papers and one round table discussion session on valence instabilities. Papers on valence instabilities and magnetic properties dominated the Conference, but there were a number of papers on electronic structure, transport and thermal properties, amorphous and liquid materials, NMR, Mössbauer and ESR, crystal field effects, and applications. The proceedings will be published in the *J. Physique (Paris).*

Most of the invited papers were well done and informative but a few were so overcrowded with detail that it was difficult for the non-expert to get much out of the talk. There were a number of excellent contributed oral and poster papers, which were of special interest to me. It was scientifically and technically an exciting, informative and profitable Conference. It was good to meet and visit with and to discuss items of mutual interests with my old friends, and to make new friends with those scientists with whom I had not yet personally met prior to this Conference.

Before the Conference, I was able to visit one laboratory and then a second one before returning to the U.S.A. The first stop on my itinerary was the Laboratorium für Festkörperphysik, Eidgenössische Technische Hochschule (ETH) in Zürich, Switzerland. Most of the time was spent with Prof. P. Wachter and his group, especially Dr. E. Kaldis, in discussions concerning rare earth semiconductors and semimetallic compounds, such as TmSe, EuSe, GdP, etc. Several of these compounds are mixed valence compounds, i.e. the rare earth element has an overall valence intermediate between 3 and 2. Most of their current activities are concerned with TmSe base alloys. At room temperature TmSe exists from a Tm:Se ratio of 0.87, where Tm's valence is 3.0, to a ratio of 1.05 where Tm's valence is 2.71. At the 1:1 stoichiometry the Tm has a valence of 2.75. The lattice parameter change across this solid solution range varies by 1.7%. This change is one to two orders of magnitude larger than is found in solid solution ranges for materials which have a constant valence. When Te is substituted for Se the valence of Tm decreases. At a concentration between $x = 0.2$ and 0.5 in the $TmSe_{1-x}Te_x$ system large changes in the lattice parameters (~0.1 Å) could be induced by a small application of pressure, i.e. the grinding of a sample in a mortar to prepare a powder sample for X-ray measurements was sufficient to do this.

Dr. G. Busch, who was head of the Laboratorium für Festkörperphysik at the ETH for many years, retired at the end of September. His research group is being divided into two groups, one of which is being headed by Prof. Wachter, who will continue the work on rare earth semiconductors.

The last stop in my European trip was a visit to the Zentralinstitut für Tieftemperaturforschung (ZITTF) in Garching just outside of Munich, Germany. There I discussed our on going joint research projects with Dr. C. Probst, with whom we are collaborating (along with Dr. J. Wittig at Kernforschungsanlage Jülich) on the superconductivity of Sc at high pressures ($T_c = 0.35$ K at 210 kbar), and with Dr. K. Neumaier, with whom we are collaborating on the low temperature (<1 K) heat capacity of Lu-H solid solution alloys. One of the groups at ZITTF is using $PrNi_5$ to reach milli Kelvin temperatures (0.001 K) by adiabatic magnetization cooling. $PrNi_5$ is a promising refrigerant for attaining low temperatures and is being used in at least a dozen laboratories throughout the world.

Nutritional Markers

A study of the feasibility of using a mixture of lanthanide oxides as a nutritional marker in humans has uncovered evidence of either single or two physiologic compartments in the human alimentary tract according to T. D. Luckey, B. Venugopal, D. Gray and D. Hutcheson [*Nutrition Reports International* **16**[3], 339-47 (1977)]. Using a mixture of Tb_4O_7, Sc_2O_3, La_2O_3, Eu_2O_3, Sm_2O_3, Dy_2O_3, Yb_2O_3 and Tm_2O_3 as a nutritional marker the researchers hoped to determine the transit time, rate of passage and recovery in humans eating their usual food. Two of the four subjects retained the markers almost twice as long as the other two which could suggest a single compartment versus a two compartment alimentary tract. Other possible causes include individual idiosyncrasies and diet composition. The difference could not be correlated to age, sex, height, weight, exercise or eating habits. These results clearly establish the feasibility of lanthanide oxide mixtures as nutritional markers in humans and point to further experiments that will help determine what affects the rate of passage in humans.

ANALYTICAL AWARD


V. A. Fassel

Dr. V. A. Fassel, deputy director of Ames Laboratory and professor of chemistry at Iowa State University, is the recipient of the American Chemical Society's Award in Analytical Chemistry. The award cites his research on trace analysis of rare earths in complex materials and development of flame emission and X-ray excited optical fluorescence techniques and spectrometric determination of gases in metals. This research has earned Fassel numerous awards over the years, including a Distinguished Professorship at Iowa State University. Fassel is active in several national and international scientific societies.

RE's in the News

Better Laser

International Laser Systems, Inc., Orlando, Florida, has developed a pulsed Nd:YAG-pumped dye laser which delivers ten times the power output of currently available commercial laser systems. The laser has a 500- to 900-nm wavelength range. Possible applications include underwater illumination and medical research.

Shiva at Full Power

Lawrence Livermore Laboratory's Shiva laser system focused 26 trillion watts of optical power in 95 picoseconds on a deuterium pellet in its first full power fusion experiment. A record 7.5 billion fusion reactions were recorded.

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Anomalous Absence

Due to the fact that the iron atoms in the compounds $CeFe_2Si_2$ and CeFeSi have identical environments made up of four silicon atoms in the form of a tetrahedron, E. M. Levin, R. V. Lutsiv, G. V. Popov and S. I. Yushchuk have undertaken a comparative study of the state of the electron shells of the iron atoms in these compounds [*Pis'ma Zh. Eksp. Teor. Fiz.* **26,** 740-2 (1977); Eng. Trans.—*JETP Letters* **26,** 576-8 (1977)]. Using nuclear gamma resonance spectroscopy they observed a narrow absorption line at near zero velocity, negative isomeric shifts relative to Fe^{57} and no Zeeman splitting. Since both compounds order magnetically these results indicate that there is a magnetic moment associated with the iron electrons but no effective magnetic field at the iron atom nuclei. The authors suggest that mutual cancellation of the contributions of the *s* electrons is caused by the covalent character of the bond between the iron and silicon atoms.

Magnetic Semiconductor Conference

An international meeting on magnetic semiconductors has been scheduled for September 10-13, 1979 in Montpellier, France as a satellite conference of the 1979 International Conference on Magnetism (September 3-7, 1979 at Munich, West Germany). The conference will attempt to summarize the recent developments in the study of insulating and metallic materials. Topics will include optics and photoemission; critical phenomena and phase transition; local environment, stoichiometry and defects; transport; magnetic excitation; and band structure calculation and theory.

The number of participants will be limited to 120 and the registration fee is 250 F.F. (~$60) which includes the cost of the conference proceedings. The proceedings will appear in a special issue of the *Journal de Physique, (Paris).* The official languages will be English and French. Abstracts are due May 1, 1979 and accepted papers will be due July 15, 1979. For additional information contact:

Dr. J. P. Lascaray, C.E.E.S.
Université des Sciences
Place E. Bataillon
34060 Montpellier, Cedex, France

Distinguished Professor


H. J. Svec

Dr. H. J. Svec has been named Distinguished Professor of Chemistry by Iowa State University. This appointment recognizes exceptional teaching and research activities. Svec, currently the program director for chemical physics at Ames Laboratory, served as a chemist on the Manhattan Project at Iowa State University during World War II. He is best known for his work with mass spectroscopy for both research and analysis of many different materials, including the rare earths.

Permanent Magnet Report

Wheeler Associates, Inc. are in the process of preparing a confidential, multi-client, in-depth, international overview of rare earth cobalt permanent magnets. The report will include world markets—present and future; history of development and current R & D programs; case histories of production applications; review of manufacturing processes; assessment of world-wide producers; status of raw material supply and prices; technical progress in materials, devices and systems; and an executive summary which contains observations on the potential growth and relationships of all permanent magnet materials.

For more information call or write:
Mr. Port Wheeler
Wheeler Associates, Inc.
120 North Mulberry Street
Elizabethtown, KY 42701
Telephone (502) 765-6773

RE BULLETIN

The *Rare Earth Bulletin*, an interdisciplinary abstracts journal published by Multi-Science Publishing Co., Ltd., has recently named K. A. McEwen, University of Salford, U.K., as its new editor. The bulletin is issued bimonthly with annual subject and author indices. Subscriptions are available from Multi-Science, The Old Mill, Dorset Place, London E15 1DJ, England at $106.00 per year.

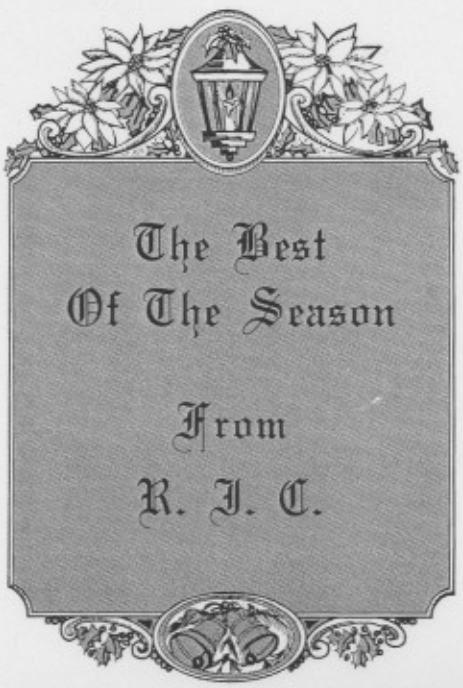
Articles are abstracted from journals dealing with chemistry, physics, electronics, ceramics,

(continued on page 4)

the study that still needs to be done, Ø. Fischer has published a state-of-the-art review concerned with Chevrel phase research [*Appl. Phys.* **16,** 1-28 (1978)]. The many unusual properties of the ternary molybdenum chalcogenides are reviewed with special emphasis on the superconducting properties including critical temperature, critical field and coexistence of superconductivity and magnetism. In addition to the above mentioned properties, the chemistry, structure, preparation, electronic properties, lattice properties and possible applications are discussed. The lattice parameters and superconducting critical temperatures of many (including rare earth) Chevrel phases are given in tabular form.

RE Bulletin
(continued from page 3)

magnetics, crystallography, optics, earth sciences, solid state, metallurgy, and materials science. The abstracts are organized into eight major categories: Distribution and Extraction, Chemical Properties, Phase Equilibria, Crystallography, Nuclear Properties, Solid State, Mechanical and Acoustic Properties and Applications.



electronic and high vacuum devices, and in extended life nuclear energy powered cardiac pacemakers. Ronson Metals was the first in the industry to produce high purity rare earth metals and alloys in the form of finely divided powders.

Ronson Metals takes pride in its production skills and has often pioneered in the development and use of specialized equipment needed in working with rare earth metals. It was the first in the rare earth metal field to use X-ray emission spectroscopy for routine quality control of its products. The most modern and efficient production equipment is used to insure uniformly high quality output.

Ronson Metals, which was established in 1915 primarily as a producer of lighter flints, continues to remain expansion-minded after almost sixty-five years of unbroken rare earth metal activity, finding itself involved, in addition to its original business, in the metallurgical, electronic and chemical industries.

Catalogues of rare earth products and other product lines are available from Ronson Metals Corporation, 55 Manufacturers Place, Newark, NJ 07105. Telephone (201) 589-1380.

EDITOR'S NOTE:

This is one of a continuing series of features on rare earth industry. The information contained herein was supplied by the company featured and its publication should not be construed to constitute an endorsement by RIC or Iowa State University of the products or services offered by the company.

428 pp, $9.50), a critically evaluated compilation of atomic energy levels for 66 atoms and atomic ions of the fifteen elements, lanthanum through lutetium inclusive. This 9½″ x 12″ volume is available from the U. S. Government Printing Office, Washington, D.C. 20402 and is part of a continuing program at the National Bureau of Standards to evaluate and compile the atomic energy levels, spectral wavelengths and classifications of all the elements and fills a noticeable void in the libraries of rare earth researchers who have had occasion to work with energy levels. Only experimentally determined energy levels are included and energies are restricted to outer shell electron excitations and inner shell excitations up to the soft X-ray range. Data given for each atom or ion include the level value, parity, *J*-value, configuration and term assignments, experimental *g*-value, leading percentages and ionization potentials. Preceding the table of data for each atom or ion is a summary which includes basic data, comments and references. The following information is also presented in tabular form: the allowed terms for *L-S* coupling of equivalent electrons, the allowed *J*-values for ℓ^N_j equivalent electrons (*j-j* coupling), corrected Lande *g*-values for terms of both even and odd multiplicity, and the Lande *g*-values for terms of both even and odd multiplicity in order of increasing value.

Rare-Earth Information Center
Energy and Mineral Resources Research Institute
Iowa State University
Ames, Iowa 50011