Recovery of a metal from process scrap and the waste from the communit has been practiced since antiquity. However, with the advent of more sophisticated ways that metals are used as a result of more complex alloying, composite structures, plating, brazing, etc., the problems sociated with reprocessing scrap and reclaiming of metals have become increasingly complex and difficult. The nature of these problems with today's materials is illustrated by consideration of the recovery of copper, zinc and iron from solid waste.

17. Metallurgy: Whence and Whither?
100 Years of Metallurgy

(Sponsored by the Institute of Metals Division)

9:00 am

Regent Room
(New York Hilton)

Chairman: J. H. Westbrook, Project Analyst, General Electric Research and Development Center, P.O. Box 8, Schenectady, N. Y. 12301

1. 100 YEARS OF METALLURGY-PROCESS METALLURGY: John F. Elliott, Massachusetts Institute of Technology, Cambridge, Massachusetts.

The field of Process Metallurgy went through a radical change in the period from 1850 to 1900 because of the development of quantitative analytical methods. As a result, the ability to work with mass balance thermochemistry and stoichiometry caused the shift of emphasis to the quantitative and away from the "Art". Electrometallurgy also came into being. The newly founded Departments of Mining and Metallurgy at a numb of Universities provided the intellectual leadership and trained manpowe for the revolution. Between 1900 and 1930, the field changed slowly and the "art" of processing regained its influence. Since 1940, the change has been evolutionary with a new emphasis on the quantitative through physical chemistry and kinetics. The evolution continues the emphasis on shifting to process analysis, computer simulation and dynamic contro

2. ONE HUNDRED YEARS OF METALLURGICAL CHEMISTRY: R. A. Swalin, University of Minnesota, Department of Chemical Engineering and Materials Science, Minneapolis, Minnesota 55455.

The status of the field of metallurgical chemistry is explored in the context of the heritage of the past one hundred years of scientific research. An attempt is made to delineate critical advances over the past century and to examine some of the thought processes of researchers in terms of the level of understanding as it existed.

3. PHASE TRANSFORMATIONS RESEARCH: A HISTORICAL REVIEW: H. I. Aaronson and K. R. Kinsman, Ford Motor Company, Dearborn, Michigan 48121

The history of research in phase transformations is traced from the days of Sorby to present in terms of key theories and experimental observations and techniques. Trans formations thus considered include the precipitation, massive, cellular and eutectoi bainite, spinodal and martensite reactions. Important problems not yet solved are pointed out for each reaction. A few examples of erroneous ideas which significantl affected subsequent research are also noted. The general conclusion is reached that the combination of theory and experimental technique now available is sufficiently powerful so that the rapid rate of acquisition of understanding which presently obtai is likely to continue for some time to come.

4. MECHANICAL PROPERTIES OF METALS, 1871-1971: W. C. Leslie, Fundamental Research Laboratory, U. S. Steel Corporation, Monroeville, Pa. 15146

The mechanical properties of the metallic materials of construction available in 1871 are reviewed. The critical developments since that time, the false trails, and significant but unnoticed contributions are described. Human-interest items and anecdotal material are included. The talk concludes with a brief survey of the mechanical properties of metallic materials now available.

5. ALLOY PHASES AND STRUCTURES: B. Giessen, Professor, Northeastern Univeristy, Boston, Mass.

18. Uranium Extraction

(Sponsored by the Uranium, Rare Earth, and Minor Metals Committee of EMD)

9:00 am

Nassau A
(New York Hilton)

Chairmen: J. L. Drobnick, Director of Process Research, Molybdenum Corp. of America, P.O. Box 607, Louviers, Colo. 80131

J. A. Abramo, Mill Superintendent, Humble Oil Refining Co., Minerals Div., 311 East A Street, Casper, Wyo. 82601

1. RECOVERY OF URANIUM FROM MINE WATER BY COUNTERCURRENT ION EXCHANGE: D. R. George and J. R. Ross, Bureau of Mines, Salt Lake City, Utah 84112

New types of countercurrent ion exchange columns developed by the Bureau of Mines were tested for recovering uranium from mine water in the Ambrosia Lake district of New Mexico. During one year of field testing, approximately 5 million gallons of mine water containing 10 ppm U_3O_8 was processed through a compartmented and upflow-type, ion exchange column of 1-square foot area at flowrates up to 25 gallons per minute. Uranium recoveries averaged in excess of 98 percent at resin loadings up to 3.6 pounds of U_3O_8 per cubic foot. Uranium was eluted from the resin in a 4-inch diameter, continuous elution column using only 2 volumes of NaCl-$NaHCO_3$ solution per volume of resin. Compared with existing ion exchange equipment and techniques now used for recovering uranium from mine water in the Ambrosia Lake district, use of these improved types of ion exchange columns would result in more complete uranium recovery and higher resin loadings while reducing equipment and resin requirements as much as 80 percent.

2. **CO-EXTRACTION OF URANIUM AND THORIUM FROM SULPHURIC ACID SOLUTIONS AND RECOVERY BY SELECTIVE STRIPPING: G. M. Ritcey, B. H. Lucas, Department of Energy, Mines and Resources, Ottawa 1, Ontario.**

Thorium and the rare earths are found associated with uranium at Elliot Lake, one of t major uranium-producing areas in Canada. Uranium is recovered by ion exchange and the resultant barren solution is neutralized to remove thorium prior to rare earth processing. The work described in this paper shows that uranium and thorium can be co-extracted from an acid sulphate solution using a primary amine such as Primene JM-T. After removal of trace amounts of co-extracted iron from the loaded extract with dilut nitric acid, the thorium and uranium are subsequently recovered as high purity salts by selective stripping of uranium with 1.0 HNO_3, and the thorium with 10% HNO_3. An estimate of the total operating costs for the recovery of uranium and thorium by solvent extraction and denitration is 12.8¢ per lb. U_3O_8.

3. THORIUM METAL PRODUCTION: G. G. Briggs and J. H. Cavendish, National Lead Company of Ohio, Cincinnati, Ohio 45239

Modifications to the Ames ThF_4 reduction process for the production of thorium metal were developed to make the operation safer and capable of producing higher quality metal.

The improvements developed included:

1. A precipitation process for production of dense crystalline ThF_4 amenable to rapid filtration and efficient washing.
2. Use of nonhygroscopic ZnF_2 instead of $ZnCl_2$ as a source of zinc in the reduction charge. This greatly reduced the potential for hydrogen generation by reaction between moisture and the calcium metal in the charge, thereby reducing the explosion hazard (especially in the charge blending operation).
3. Use of ZnF_2 in the reduction process also made it feasible to use CaF_2 slag from the reaction as liner material for the reduction vessels. This development significantly improved the purity of the metal produced.

The process developed has been in routine production at NLO for several months.

4. THE INFLUENCE OF LEACHING VARIABLES IN ALKALINE CARBONATE LEACH OF URANIUM ORE: R. G. Dakers, Project Metallurgist, and T. W. Zawidzki, Project Chemist, Eldorado Nuclear, Ltd., Suite 800, 151 Slater Street, Ottowa 4, Ontario, Canada

5. SOLVENT EXTRACTION EQUILIBRIUM DATA FOR THE SYSTEM $SmCl_3$-$NdCl_3$-$CeCl_3$-HCl-H_2O WITH Di -- (2-Ethylhexyl) PHOSPHORIC ACID AS THE SOLVENT: R. G. Bautista, Ames Laboratory, Iowa State University, Ames. Iowa 50010

19. Thermodynamics III

(Sponsored by the Physical Chemistry Committees of ISD and EMD)

9:00 am

Nassau B
(New York Hilton)

Chairmen: R. D. Pehlke, Dept. of Chemical and Metallurgical Engineering, Univ. of Michigan, Ann Arbor, Mich. 48104

T. C. Wilder, Ledgemont Labs., Kennecott Copper Corp., Lexington, Mass. 02173

1. GALVANIC CELL STUDIES USING THE β-ALUMINA SOLID ELECTROLYTE: G. R. Belton, School of Metallurgy and Materials Science, University of Pennsylvania, Philadelphia, Pennsylvania 19104 and P. T. Morzenti, Western Electric Company, Inc., Allentown, Pennsylvania 18103

β-Alumina, which has a layered structure consisting of spinel-like blocks separated by loosely packed layers of sodium and oxygen ions, has a very high sodium ion conductivity. This property has led to its use in high temperature fuel cells. The value of this solid electrolyte for thermodynamic studies has been investigated by measurements on liquid sodium-lead alloys. The results obtained are shown to be reproducible, precise, and in agreement with previous work by other techniques.

2. THERMODYNAMICS OF MAGNESIUM-ANTIMONY SYSTEM: B. V. Patil and Y. K. Rao Henry Krumb School of Mines, Columbia University, S. W. Mudd Building, New York, N. Y. 10027

The changes in the free energy, entropy and enthalpy accompanying the formation of liquid magnesium-antimony alloys at temperatures ranging from 730° - 950° C, were investigated using th reversible galvanic cell: $Mg(l)/Mg^{++}$ (in KCl + NaCl eutectic +25% $MgCl_2$)/Mg in Sb(l). The electromotive force measurements encompassed both the single phase and the two phase regions. activities, partial and integral molar properties of magnesium and antimony were ascertained at 800°C. The activity curves exhibit a strongly negative departure from Raoultian behaviour. All alloys are formed exothermically, and the enthalpy of formation has a minimum of - 12.7 K Cals/g atom at 28 atom percent antimony. The formation of the alloys is associated with a release of fre energy over the entire range of composition, the minimum of - 9.8 K Cals/gm. atom occurring at the composition $X_{Sb} = 0.4$ corresponding to that of the intermetallic compound. The enthalpy an entropy of formation of Mg_3Sb_2(s) referred to pure solid elements were derived from the experimen results and the phase diagram for the Mg-Sb system. These values are:
$\Delta H^o_s = - 76{,}880$ cals/gm. mole at 800°K, $\Delta S^o_s = - 7.6$ cals/gm. mole/°K at 800°K.

3. THERMODYNAMIC PROPERTIES OF LIQUID Cu-O, Cu-O-Ni, and Cu-O-Fe SYSTEM
A. D. Kulkarni and R. E. Johnson, Chase Brass & Copper Co., Clevelan
Ohio 44106

Oxygen activities have been measured in liquid copper by the solid oxid electrolyte E.M.F. technique with Ni-NiO and Co-CoO as reference electrodes. The dissolved oxygen content in a molten copper bath was varie by bubbling through CO or a CO/CO_2 mixture. Metal samples were withdrawn, quenched, and analyzed for dissolved oxygen in a high-accuracy gas analysis unit. The investigation was carried out at 1100, 1200, an 1300°C and at oxygen concentrations from 10 to 10,000 ppm. The results obtained compared favorably with the literature. The effect of a third component (Ni or Fe) on the activity coefficient of oxygen in molten copper was also studied. In these experiments initial oxygen content in liquid copper was adjusted to approximately 50 or 1000 ppm. Interaction coefficients $\varepsilon_O^{(Ni)}$ and $\varepsilon_O^{(Fe)}$ were determined at 1100, 1200, an 1300°C.

4. ACTIVITIES IN LIQUID Fe-Ti-O ALLOYS: R. J. Fruehan, Fundamental Research Laboratory, U. S. Steel Corp., Monroeville, Pa. 15146

The solubility and activity of oxygen in Fe-Ti melts at 1600°C were measured. The activity was measured electrochemically using the following galvanic cells:

$Cr\text{-}Cr_2O_3(s)\ |ThO_2(Y_2O_3)|\ Fe\text{-}Ti\text{-}\underline{O}(\ell$, saturated with oxide)

$Cr\text{-}Cr_2O_3(s)\ |ZrO_2(CaO)|\ Fe\text{-}Ti\text{-}\underline{O}(\ell$, saturated with oxide)

Titanium decreases the solubility of oxygen in liquid iron to 40 ppm at 0.9 wt.% Ti. The value of the interaction coefficient $\varepsilon_O^{(Ti)}$ is -222 and the activity coefficient of titanium at infinite dilution in liquid iron is 0.038. The thermodynamic behavior of oxygen in liquid ternary iron-base alloys containing Al, B, Cr, Ti or V is discussed.

20. Pyrometallurgy III—General Pyrometallurgy

(Sponsored by the Pyrometallurgy Committee of EMD)

9:00 am

Gibson Room
(New York Hilton)

Chairmen: C. B. Magee, Denver University, Denver, Colorado
R. R. Beck, Kennecott Copper Corporation