

hydrides, Si_2H_n , where $n = 0-6$ and Si_2H_n^+ , where $n = 0-7$. The calculated thermodynamic properties of the neutral species were in agreement with experimental data reporting the existence of stable silicon hydrides having n values of 2-5.

An interesting study was made in collaboration with the Central Institute of Inorganic Chemistry, Berlin, Germany, on MAlF_4 complexes where $M = \text{H}, \text{Li}, \text{or Na}$. These complexes are involved in high-temperature industrial processes, catalysis, chemical synthesis, and metal halide lamps. Investigations were conducted on the three structures shown in Fig. 6-36, in which the Al-M atoms are bridged at the corners, edges, or faces of the structure. Edge and corner bridging in HAlF_4 are of about equal energy (0.4 kJ/mol); LiAlF_4 has an edge-bridged structure; and the edge- and face-bridged structures of NaAlF_4 are of nearly equal stability. The HAlF_4 complex is much less stable than the alkali complexes, which may be a reason why difficulties have been encountered in observing this molecule.

In 1992, the CMT Annual Report stated that "The Gaussian-2 (G2) theoretical procedure, developed in a collaborative effort with AT&T Bell Laboratories and Carnegie Mellon University, is beginning to receive (1) wide acclaim for its accuracy in calculating molecular energies, and (2) extensive use in the field of computational chemistry." The G2 theory was being used widely by universities and industry for calculations of thermochemical data. The

method is accurate to ± 2 kcal/mol for calculating reaction energies. In 1992, the procedure was used in the modeling of thin-film diamond growth mechanisms, based on carbon dimer as the growth species. The model involved the formation of diamond-like carbon clusters by reactions of carbon with hydrocarbons.

By 1995, the G2 procedure had been extended to the elements Ga \rightarrow Kr of the third row of the periodic table. Spin-orbit corrections for atoms and molecules having partially degenerate states were included explicitly in the G2-calculated energies. The average absolute deviation from experimental values for 40 test reactions was 1.37 kcal/mol.

An enlarged G2 neutral test set of 148 molecules was used to assess the performance of the G2 theory and two modified versions of it, G2(MP2) and G2(MP2,SVP). The mean absolute deviations for the three theories were 1.58, 2.04, and 1.93 kcal/mol, respectively. All three theories achieve the desired chemical accuracy of 2.0 kcal/mol. The modified versions, G2(MP2) and G2(MP2,SVP), are slightly less accurate than the original G2 theory, but they require significantly less computer time and disk space.

Personnel. Larry Curtiss was the Division's leader in this area. Some of the others who had a particular interest in this work were Milt Blander, Vic Maroni, Chris Marshall, Zoltan Nagy, Jerry Rathke, Marie-Louise Saboungi, and Shiu-Wing Tam.

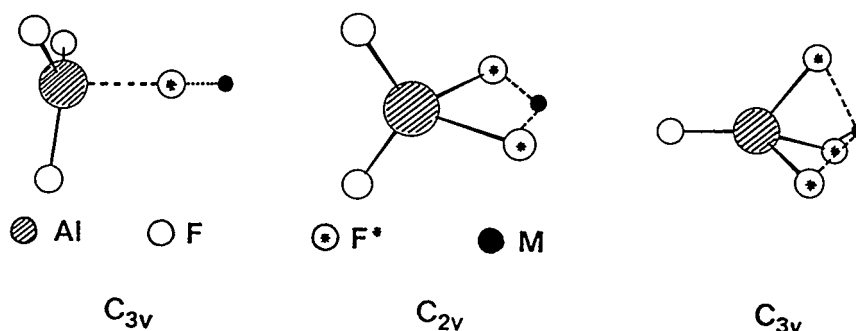


Fig. 6-36. Illustration of MAIF_4 Structures

MOLECULAR SIEVE RESEARCH

Advances in the synthesis of novel molecular sieve materials had paved the way for product-selective catalysis in the processing of fuels and chemical feedstocks. The CMT work in this area consisted mainly of theoretical studies of molecular sieve synthesis. Much of this work was based on the type of molecular orbital calculations discussed in the preceding section.

Ab initio molecular orbital calculations and inelastic neutron scattering techniques were used to determine the effects of the molecular sieve framework on the vibrational frequencies and rotational diffusion of occluded template molecules. The potential energy surface of tetraethyl-ammonium cation for rotation about the C-C and C-N bonds showed no distinct configurations that corresponded to local minima of approximately equal energy. Another study was made to investigate the Brønsted acidity of $\text{Si}_n(\text{OH})_m$ clusters similar to those in molecular sieves. Proton affinities, which are an important factor in defining Brønsted acidity, were calculated with accuracies of 5-10%. This made possible a direct correlation of calculated O-H bond strength with observed catalytic activity.

The characteristics of clusters containing up to 160 atoms were calculated by the G2 theoretical procedure—some of the largest clusters ever used in electronic structure calculations on zeolites. Proton affinities, ammonium-ion affinities, and ammonia desorption energies were determined for these clusters. The calculated values for the properties of zeolites and molecular sieve materials were in good agreement with experimentally determined values that were available.

Continuing studies produced two significant findings. First, the energetics of the Brønsted acid site in TSi_nO_m clusters, where $T = \text{Si}$ or Al , that have zeolite-type structures

were calculated, and key properties of structures that are strongly correlated with the acid catalyst performance of zeolite materials were determined with unprecedented accuracy. Second, zeolite frameworks having sulfided metal clusters in void regions of the crystal structure were found to catalyze the conversion of methane to higher hydrocarbons. The reaction rates were low, but the selectivity to produce C_{2+} hydrocarbons was close to 100%.

In the hydrocarbon cracking process used by the petroleum industry, proton transfer between the adsorbed molecule and the zeolite catalyst was known to be a key mechanism. To understand the energetics of proton transfer and acid catalysis in zeolites, the equilibrium geometries of protonated alkanes (carbonium ions) were investigated, and their proton affinities were calculated using the G2 theory. For protonated ethane, the calculated proton affinity of the lowest energy structure was 141.0 kcal/mol, which agreed well with the experimental value of 139.6 kcal/mol. Proton transfer from the Brønsted acid site to an adsorbed molecule was believed to be a key mechanism not only for hydrocarbons, but also for other molecules such as water, ammonia, and methanol. In the case of water, the structure resulting from proton transfer to an adsorbed water molecule was found to exist only as a transition state, but the adsorption of a second water molecule stabilized the proton transfer structure, creating a local minimum in the potential energy surface (a more stable arrangement). The study was then extended to the interaction of the water dimer with the acid site in the zeolite ZSM-5 to a five-metal atom cluster ($\text{AlSi}_4\text{O}_4\text{H}_{12}$) model. Equilibrium geometries of the neutral $[\text{ZH}\dots(\text{OH}_2)_2]$ and ion-pair $[\text{Z}\dots\text{H}(\text{OH}_2)_2]^+$ adsorption complexes were calculated, as well as the transition geometries between these two species. Density function theory was used for these calculations. While not quite as accurate

as G2 theory, it is more cost-effective. The relative energies of the two species and the transition state were small, indicating free movement of the proton.

Recent work in this area had shown some particularly noteworthy results on interactions of ethane with zeolite clusters. The $\text{H}_3\text{SiO(H)Al(OSiH}_3)_4$ cluster model, which includes five tetrahedral atoms, allows an adsorbed molecule to interact with three oxygen atoms adjacent to the substituted aluminum site. Calculations have identified several stationary points on the potential energy surface for the interaction of methane with the zeolite acid site (ZH). The calculations provide evidence for the existence of a stable ion-pair structure ($\text{Z}^-\dots\text{C}_2\text{H}_7^+$), whose existence had been contested. In addition, a new calculated value for the proton transfer barrier from the zeolite to the adsorbed hydrocarbon is in much closer agreement with typical experimental values than had been obtained previously.

Personnel. This work was done by Vic Maroni, Larry Curtiss, L. Hon, and Stan Zygmunt (an STA).

ELECTROCHEMICAL AND CORROSION STUDIES

Spectroelectrochemical and Synchrotron Studies. As mentioned earlier, a combination of spectroscopic and electrochemical techniques can be highly synergistic in understanding the detailed mechanisms of corrosion reactions and other chemical processes. The spectroelectrochemical investigations described in this section used a battery of such techniques: (1) laser Raman and UV-visible spectroscopy to determine *in situ* the structures and compositions of anodically formed corrosion films on metals, (2) photoelectrochemical and ac impedance measurements to characterize the electronic band structures of the films and to study their

transport properties and conduction mechanisms, and (3) ac and dc polarization, cyclic potentiodynamic sweeps, and other transient techniques to examine the interfacial processes involved in metal corrosion. The synchrotron studies in this program were collaborative efforts with outside organizations, including Exxon Research and Engineering Co., the Naval Surface Warfare Center, the University of Poitiers in France, the University of Auckland in New Zealand, and members of the ANL Materials Science Division. Some of the research in this area was oriented toward possible future use of the Advanced Photon Source, which was under construction at ANL.

Surface enhancement of Raman scattering (SERS) by electrodeposition of silver showed that the passive films on iron consist of an inner layer of Fe_3O_4 and Fe(OH)_2 and outer layers of $\alpha\text{-Fe}_2\text{O}_3$ and FeOOH , depending on the potential. Small amounts of thiocyanate (SCN^-) were found to break down the passivating oxidic layers on iron by complexing Fe^{2+} and Fe^{3+} ions, with subsequent precipitation of iron thiocyanate phases. At thiocyanate concentrations below about 0.001 M, however, the iron oxide films were self-healing, thereby preventing catastrophic breakdown. A similar study of the passive film formed on nickel showed that the film was composed of both Ni(OH)_2 and NiO , probably as a bilayer structure with the NiO closer to the metal. In subsequent studies at temperatures from ambient to 95°C, Fe(OH)_2 and Fe_3O_4 formed in the prepassive region, while Fe_3O_4 and FeOOH predominated at passive potentials.

In the case of chromium, a near-monolayer oxide film of Cr_2O_3 was formed. At more positive potentials (>0 V vs. the saturated calomel electrode), there was evidence of Cr(VI) in the form of a soluble chromate. A copper electrode in NaOH solution at -0.05 V vs. the standard calomel electrode formed a surface film of Cu_2O . Other work on copper

involved studies of electrochemically induced pitting and morphological studies of its electrodeposition, and the behavior of copper in dilute solutions of cyanate (OCN^-) and thiocyanate (SCN^-) in perchlorate supporting electrolyte.

X-ray near-edge spectroscopy (XANES) and extended X-ray absorption fine structure (EXAFS) studies were made on the higher oxide forms of nickel (β -NiOOH, γ -NiOOH, and NiO_2). These materials were of interest both for corrosion protection and as battery electrode materials, and there was confusion in the literature as to the structure and valency of the nickel in these compounds. X-ray absorption measurements showed that all three of the higher oxide forms of nickel had the same disordered, layered structure, which can be represented as NiO_2H_x ($0 < x < 2.0$). Spectroscopic results indicated that the β and γ forms of NiOOH should be regarded as Ni^{3+} compounds. In subsequent studies, synchrotron X-ray absorption was used to characterize further the various phases that could be formed during corrosion of the metal or during the cyclic charging and discharging of nickel electrodes in batteries. The compounds that were characterized included NiO, α - and β -Ni(OH) $_2$, β - and γ -NiOOH, $\text{Ni}_3\text{O}_2(\text{OH})_4$, NiO_2 , Ni_3O_4 , Ni_2O_3 , and KNiO_6 . Three distinct Ni-O bond distances were characteristic of Ni^{2+} , Ni^{3+} , and Ni^{4+} . In other work on nickel, an electrochemically deposited nickel oxide film on graphite was discovered to increase the capacitance of the graphite fourfold.

In situ laser Raman spectroscopy was used to investigate the compositions and structures of anodic corrosion films on titanium in various aqueous environments (H_2SO_4 , Na_2SO_4 , H_3BO_3 - $\text{Na}_2\text{B}_4\text{O}_7$, and NaCl solutions). Bands characteristic of the anatase form of TiO_2 were observed at highly anodic potentials, while a disordered amorphous film was formed under cathodic conditions.

Synchrotron-generated far infrared radiation studies of water adsorbed on gold or platinum crystals permitted detection for the first time of the hindered translational mode of water and suggested the formation of water clusters at low coverage and an ice-like layer at higher coverages. Continuing studies showed that water adsorbed molecularly and non-dissociatively on the single-crystal platinum (111) under ultra-high vacuum and low temperatures ($< -73^\circ\text{C}$). The far infrared spectrum of water on Pt (111) was very similar to that of gold.

Electrode Structure and Kinetics Studies.

This research was concentrated on the electrode kinetics and atomistic mechanisms involved in metallic corrosion in aqueous solutions over a wide range of temperatures and pressures. This was a new area of investigation, since very little electrode kinetics research had been performed at temperatures over 60°C and practically none above 100°C in aqueous solutions. Much of the interest in aqueous corrosion at higher temperatures and pressures stemmed from corrosion effects in light water reactors (LWRs). The corrosion processes are electrochemical in nature and involve anodic dissolution of the metal together with the reduction of some component of the aqueous solution, such as dissolved oxygen. In reactions of this type, the essential elementary step is the charge transfer between the solid surface and the solution species at the interfacial solution layer (the "interphase"). The kinetics of the charge-transfer step are influenced by the molecular structure of the interphase and potential gradients within it. The electrode kinetics measurements were made by a combination of techniques, including galvanostatic, coulostatic, or potentiostatic pulse transients; ac capacitance methods; and rotating disk-electrode techniques.

Earlier work had shown that a simple charge-transfer reaction does not behave anomalously at high temperatures, so discrepancies reported in the literature must have been caused by something else. The ferrous/ferric reaction was known to be catalyzed by trace levels of anionic impurities, and precautions were taken in the experiments to avoid this effect. A catalytic effect on the $\text{Fe}^{2+}/\text{Fe}^{3+}$ electron-transfer rates was observed after a single layer of copper had been plated on a gold working electrode. This effect was believed to result from the fact that the solvated ion could approach the plated surface more closely than the gold electrode.

Studies were extended to the Cu^{2+}/Cu electrode reaction, which entails two consecutive electron transfers followed by incorporation of a copper atom into the metal phase. There were two reasons for selecting this reaction for study: (1) copper deposition had been one of the most troublesome cathodic reactions in the corrosion of LWR cooling systems, and (2) the system presented a special challenge in the extension of the electron-transfer theory methods to an ion for which Jahn-Teller distortion of the hydration shell had to be accommodated. A computer modeling analysis indicated that it would be possible to measure both the fast and the slow steps of the Cu^{2+}/Cu reaction sequence. Work continued on theoretical models of Cu^+ and Cu^{2+} ions in water. Preliminary experimental measurements on $\text{Cu}^{2+}/\text{Cu}^0$ in perchloric acid solution reproduced some data in the literature. However, it became clear in the modeling studies that the calculated rate of the fast reaction in the two-step reaction sequence needed to be reevaluated.

Copper deposition is an important cathodic reaction during stress corrosion cracking in LWRs, and the mechanism was poorly understood. Experimental measurements confirmed earlier reports that the reaction rate is controlled by the $\text{Cu}^{2+}/\text{Cu}^+$ charge-transfer

step. It was also found that traces of chloride ion strongly catalyzed this reaction. The catalytic effect was attributed to the adsorption of chloride ions on the electrode surface and promotion of the charge transfer through an anion bridge. As the concentration of the chloride ion was increased, the exchange current density of the $\text{Cu}^{2+}/\text{Cu}^+$ step doubled, while that of the Cu^+/Cu step remained essentially constant. When the importance of the chloride catalytic effect was recognized, rigorous purification procedures were applied to the perchloric acid solutions, and the rate constant of the reaction decreased by two orders of magnitude. In later studies, experimental measurements indicated that the rate of the $\text{Cu}^{2+}/\text{Cu}^+$ charge-transfer reaction increased about a hundred fold when the temperature was raised from 25°C to 200°C. An Arrhenius plot for the temperature dependence of this reaction resulted in an activation energy of 30 kJ/mol.

In 1997, the kinetic studies of the Cu^{2+}/Cu electrode reaction were completed. The high-temperature/high pressure studies of the $\text{Cu}^{2+}/\text{Cu}^+$ reaction, which is the rate-determining step in the overall copper deposition/dissolution process, were extended from a maximum temperature of 100°C to 200°C. The activation energy was found to be 32 ± 5 kJ/mol, and the transfer coefficient was independent of temperature.

In 1994, a collaborative effort with the ANL Materials Science Division was continued on the use of synchrotron X-ray methods to probe electrified interfaces that were buried under or within condensed phases. X-ray reflectivity techniques had been used to look at the metal side of the interface and the structure of the solution side of the electrical double layer. A similar approach was undertaken, using a complementary technique involving X-ray standing waves (XSW). This combination of techniques permitted studies of the double layer over a concentration range of five orders of

magnitude at a distance from the electrode surface ranging from a few angstroms to tens of thousands of angstroms. A special thin-layer, X-ray/electrochemical cell capable of XSW measurements was developed. This apparatus was used to study incipient pore formation in luminescent silicon layers, which were of interest for future industrial applications due to their luminescence at visible frequencies.

Ultracapacitor Studies. A new program was started recently on the surface phenomena involved in ultracapacitor energy-storage devices. The characteristics of these devices are between those of classical “dielectric” capacitors and those of batteries. The capacity of ultracapacitors stems from three phenomena: (1) the capacitance of the electrical double layer, (2) the adsorption/desorption pseudocapacitance, and (3) the capacitance caused by oxidation/reduction processes of the electrode material occurring at or near the interface.

All of these phenomena can be investigated by means of synchrotron X-ray techniques, and initial studies are in progress on RuO_2 surfaces because this oxide, alone or with other oxides, is one of the most promising candidates for this application.

Theoretical Studies of Electrode Reactions. The investigations performed under this task were concerned with the more theoretical aspects of the electrochemical studies, but were so closely intertwined with the work in the preceding section that a separation may be rather artificial. Much of this work was done in cooperation with John Halley, a member of the Corrosion Institute at the University of Minnesota.

Theoretical models were developed for Cu^+ and Cu^{2+} ions in water. These were necessary for studying the $\text{Cu}^+/\text{Cu}^{2+}$ electron-transfer process. A pair potential was derived for $\text{Cu}^+/\text{H}_2\text{O}$ from *ab initio* molecular orbital

calculations. This potential, with one derived previously for $\text{Cu}^{2+}/\text{H}_2\text{O}$, was tested successfully in molecular dynamics simulations of these ions in water. Two- and three-body interaction energies were calculated for tetrahedral, octahedral, and cubic arrangements of H_2O molecules around Cu^+ and Cu^{2+} ions in $[\text{Cu}(\text{H}_2\text{O})_n]^q$ clusters. Previous studies of copper ions in water had not taken into account the Jahn-Teller distortion of water in the first solvation shell about Cu^{2+} . X-ray diffraction data indicated that this distortion is significant and must be included in accurate calculations. Some disagreement had arisen as to the stability of metallic copper (Cu^0) in water. High-level calculations indicated that the interaction energy was very small (<0.2 eV).

In further studies of $\text{Cu}^{2+}(\text{H}_2\text{O})_n$ clusters, the molecular dynamics results did not jibe with those from neutron-diffraction experiments. A possible explanation was a difference in the aqueous solutions used in the work. Detailed calculations were performed to elucidate the mechanism of the $\text{Cu}^{2+} + 2\text{e}^- \rightarrow \text{Cu}^0$ reaction in water. Molecular modeling studies of the electron-transfer reaction involved the multibody interactions of $\text{Cu}^{2+}(\text{H}_2\text{O})_n$ clusters.

The electron-transfer rates are dependent upon electron coupling and a weighted density of states. The electronic coupling was calculated for three possible electron-transfer reactions in the copper deposition: (1) direct interaction, (2) outer-sphere electron transfer (water-water bridge), and (3) inner-sphere electron transfer (chloride bridge). The greatest coupling was found with the chloride bridge as a result of the shorter copper-copper distance rather than intrinsic chemical effects. Research continued in this area on the effects of other anions on the electronic coupling in $\text{Cu}^{2+}/\text{Cu}^0$ electron-transfer reactions. Electronic couplings for bromine- and fluorine-bridged reactions were similar to those for water-water bridged reactions. In 1996,

investigations were conducted on the homogeneous inner-shell electron-transfer reaction $\text{Fe}^{3+} + \text{e}^- \rightarrow \text{Fe}^{2+}$ with the bridging halide anions, F^- , Br^- , and I^- . These anions gave increased electronic coupling due to a closer approach distance than is possible for an outer-sphere water bridge.

Personnel. These programs were under the general direction of Vic Maroni. Other CMT staff personnel contributing to this work included Wally Calaway, Larry Curtiss, Stan Johnson, Xiandong Feng, Carlos Melendres, Zoltan Nagy, George Papatheodorou, Gerry Reedy, and Ben Tani. This, like most of the other basic programs, made use of postdocs and other temporary personnel.

POLYMER ELECTROLYTES

This project is a fundamental study of lithium polymer electrolytes used in lithium batteries. The studies focus on the effects of the polymer host on ion pairing, which strongly affects the ionic transport in these systems. In recent work, *ab initio* molecular orbital theory has been applied to the energetic, structural, and dynamical properties of ion-ion and ion-polymer interactions at the molecular level, in combination with molecular dynamics simulations performed at the University of Minnesota. It was found that the binding energies of lithium cation complexes with alkyl oxide chains increase with coordination of the cation by oxygen, while the binding energy of the Li-O bond decreases. This theoretical study was conducted by Larry Curtiss.

GEOCHEMISTRY

The geochemistry research work was focused initially on two areas: (1) geochemistry and evolution of hydrothermal systems associated with volcanic areas, and (2) isotopic and

organic geochemistry of carbon in sedimentary basins. In 1992, a more basic effort was added on mineral-fluid interactions.

Hydrothermal Systems. The extent of disequilibrium between ^{238}U and ^{230}Th was used to investigate the rates and mechanisms of element redistribution and the time scale of hydrothermal activity. One application was to determine the ages of travertine deposits in the northern part of Yellowstone Park. Travertines are calcium carbonate deposits that are formed when saturated or super-saturated groundwater emerges at the Earth's surface. The alpha decay rate of ^{234}U (half-life = 245,000 y) to ^{230}Th (half-life = 75,400 y) provided a "clock" for determining the age of the travertine, which contained a negligible amount of ^{230}Th when it was formed, so the $^{230}\text{Th}/^{234}\text{U}$ ratio is essentially zero. The time for the ^{234}U and ^{230}Th to reach equilibrium is about 500,000 y. The age of the travertine can thus be determined from the $^{230}\text{Th}/^{234}\text{U}$ activity ratio, with an upper limit of about 500,000 y. By using this approach, travertine formation was shown to have occurred about 130,000 to 170,000 years ago. This type of information should lead to a better understanding of the timing of the last glaciation in the region and the underlying thermal systems. These studies were done in collaboration with Kenneth Pierce of the U.S. Geological Survey and M. T. Murrell, a geochemist at Los Alamos National Laboratory (LANL).

Further studies of the Yellowstone Park area included the geochemistry and isotopy of radium in the hydrothermal systems. The radium concentration proved to be controlled by barite saturation and zeolite-water ion exchange.

Other field-based studies showed that the ages of silica samples from volcanic areas in the northern Kenya Rift Valley correlated with high paleolake levels, which were

associated with humid climatic periods during the past 150,000 years. The main significance of this work is that it showed clearly, for the first time, the influence of climatic variations on geothermal activity in a continental rift zone.

Thermal springs along the shores of the Gulf of Suez and along the Nile River just south of Cairo were sampled for chemical and isotopic analysis in a collaborative study with Egyptian colleagues from Washington University and the Egyptian Geological Survey and Mining Authority. The objective was to determine the geothermal potential of these areas and their hydrogeochemical characteristics. The results showed that the Egyptian thermal waters contain water from either the Nubian sandstone aquifer or the Nile River, derived their solutes from Tertiary marine sedimentary rocks, and were heated conductively at depths of 3 to 4 km under a normal regional thermal gradient.

Mineral-Fluid Interactions. In 1992, a new project was initiated on the application of synchrotron radiation techniques to *in situ* studies of mineral-fluid interactions. A special X-ray-transparent cell that was developed for these studies is illustrated in Fig. 6-37. The cell performed well in tests at the National Synchrotron Light Source at Brookhaven National Laboratory, and initial studies were made on changes in the surface structure of calcite during dissolution and growth. These experiments on a calcite/fluid interface indicated that the structure of the calcite cleavage surface during dissolution was determined by the near-ideal, atomic-scale termination of this surface and the long-range atomic order of the underlying bulk crystal. A multistep mathematical model was developed to characterize the surface.

X-ray reflectivity and diffraction measurements were used to characterize an ovoidite over-growth as it was precipitated from aqueous solution onto a calcite cleavage

surface. Scans were made during 4,585 min (76.4 h) of growth. Reflectivity was used to determine the properties of thin films, including the thickness, interfacial roughness, and real-space electron density profile across interfaces. A growth rate of 15 Å/h during the first 540 min decreased considerably thereafter. An analysis of the results from these measurements indicated that the ovoidite had grown heteroepitaxially on the calcite cleavage surface.

X-ray standing wave measurements were made at mineral-water interfaces to provide information on the structures of metal adsorbates. Such information is needed to understand contaminant transport in ground-water aquifers. When lead was adsorbed from an aqueous solution onto the (104) cleavage surface of calcite, and the solution was then removed, approximately a 5% monolayer of lead was found adsorbed on the calcite. This lead occupied the same position as calcium relative to the (104) lattice plane. Additional experiments were conducted with solutions containing known concentrations of uncomplexed Pb^{2+} or PbOH^+ ions that were available for adsorption on the calcite surface. The conclusions from these experiments were:

1. About 5-17% of a monolayer equivalent of lead was adsorbed from the solution onto the calcite surface.
2. The amount adsorbed was independent of time from 8 to 93 h of reaction.
3. The lead occupied calcium sites.
4. The coverage and ordering of lead were about the same for *in situ* and *ex situ* measurements.
5. The adsorbed lead was stable in both aqueous solution and flowing helium for the duration of the measurements (about 96 h).

Isotope and Organic Geochemistry. A new gas chromatography/isotope ratio mass

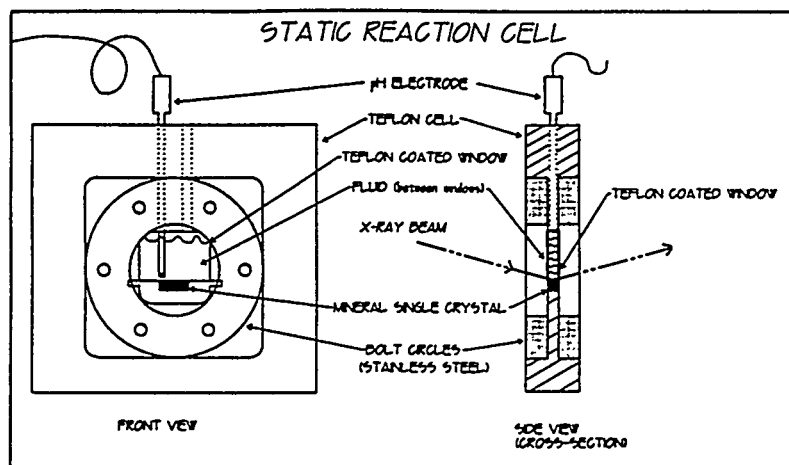


Fig. 6-37. Reaction Cell for Studies of Mineral-Fluid Reactions

spectrometer (GC/IRMS) was acquired, and a research program was undertaken in which this instrument was used for compound-specific carbon isotopic analysis in studying petroleum geochemistry. Suites of well-characterized petroleum samples were obtained from scientists at major oil companies, the U.S. Geological Survey, the Illinois Geological Survey, and several universities. Each suite was selected to address one or more of the following questions: (1) the relationship between source rock quality and the depositional environment, (2) the relationship between oil composition and source rock type, (3) the nature of chemical changes that occur within organic matter during diagenesis and catagenesis, (4) the effects of migration, mixing, and biodegradation on oil composition, and (5) the validity of oil-source rock and oil-oil correlations. Before analyzing the samples, CMT researchers spent considerable effort to test the GC/IRMS procedure, using n-alkanes of known carbon isotopic composition.

The carbon isotopic compositions of n-alkanes in oil samples from different reservoirs in an oil field near Phillipstown, Illinois, were similar. This finding is consistent with biomarker data indicating that these oils were generated from a similar

source rock, but they appeared to have undergone varying degrees of biodegradation.

Although the chemical and isotopic compositions of hydrocarbon compounds in petroleum had been well studied, the geochemistry of nitrogen compounds in petroleum was another story. Therefore, some studies were conducted on nitrogen-rich crude oils in California. Nitrogen isotope determinations on 25 well-characterized nitrogen-rich crude oils showed that the sulfur-rich oils derived from marine-dominated organic matter had relatively low ^{15}N contents, while the sulfur-poor oils from organic matter containing some terrigenous material was high in ^{15}N . Variations in the nitrogen isotopic compositions were attributed to differences in the depositional environment, rather than to biodegradation or maturation processes.

Personnel. This effort, as in the past, was led by Neil Sturchio, and it included Teofilo Abrajano, Greg Archart, Allen Bakel, Ron Chiarello, Ben Holt (STA), Wally Calaway, Pete Lindahl, and Francis Markun, and several postdocs were also involved in certain aspects of the work. This was a highly collaborative program with many other institutions, several of which are in foreign countries.

ENHANCED METALLURGICAL PROCESSES

A small effort was continued on the use of molten sulfide mixtures to extract copper from scrap steel. For the production of sheet steel from scrap, the copper content of the material must be reduced to a level below 0.1 wt%. Measurements were performed at temperatures of 1365-1400°C on high carbon steel in equilibrium with mattes consisting of 80-90 wt% Al_2S_3 , 10-20 wt% FeS , and 0-10 wt% MgS or CaS . For a steel/matte weight ratio of 4, the copper contents of the steel ranged from 0.04 to 0.09 wt%, where the initial values were 0.4 wt%. This procedure met the requirement of <0.1 wt% in the product, but required a large amount of matte. Investigations were then started on possible silicate-based slags that would remove copper from the steel, since silicate slags are already used widely in the industry.

Molten salts were also developed for the removal of lead from solid brass and copper surfaces. Treatment with the molten salts removed >90% of the surface lead from polished lead-bearing brass. Tests of treated brass samples by the EPA showed that this method of lead removal could be used for the pretreatment of brass parts in water systems.

This work, led by Milt Blander, was done by temporary personnel.

Analytical Chemistry Laboratory (ACL)

The Analytical Chemistry Laboratory continued to operate much the same as before, serving the Division, other projects at the Laboratory, various Federal agencies, and some private organizations. Dave Green continued to manage the organization. Fred Martino provided technical and quality assurance support for ACL and was the ANL Quality Assurance Representative for the Division. He was also responsible for a

variety of administrative functions for ACL. Dave has become recognized as an authority on management of an analytical laboratory, and he has addressed various aspects of the subject in seminars and publications.

The organization consists of four groups—Chemical Analysis, Instrumental Analysis, Organic Analysis, and Environmental Analysis. The Group Leaders, respectively, are Don Graczyk, Del Bowers, Amrit Boparai, and Peter Lindahl. The ACL, like the rest of the Division, felt the effects of a shrinking budget. From 1990 to 1998, the technical staff level of the ACL decreased from about 50 to 35 or so. During that period, there was also a shifting emphasis in the nature of the analytical work that was needed. In the early 1990s, processing and recycling of IFR fuel was a major development effort that required extensive analytical work to evaluate the performance of the process operations. At the time that the IFR program was terminated, there was a rapidly growing interest in environmental and waste processing programs. The Division's programs up to that time had been concerned largely with inorganic and metallurgical materials. Many of these new program areas involved organic chemistry, and the ACL responded with a wide variety of new analytical capabilities for organic materials.

Upgrading and expansion of the ACL facilities and equipment continued in the 1990s. A computer-assisted bar code system was adopted for sample tracking and handling. A new laboratory was made available for analytical work on radioactive organic samples. In 1993, quality assurance and control procedures were developed to satisfy DOE and EPA reporting requirements. Among the new equipment items were a microwave digestion system, an automated C/H/N analyzer, a new mass spectrometer for organic analysis, an interfacing liquid chromatography/mass spectrometer for determining organic compounds, an

inductively coupled plasma/mass spectrometer, a laboratory robotics system, a mercury analyzer, an oxygen combustion vessel for determining trace metals in water and environmental samples, a liquid scintillation counter for α and β activity, a germanium detector for γ -emitting nuclides, an upgraded scanning electron microscope user facility, a new X-ray diffractometer system, and Fourier transform infrared and Raman spectrometers.

In 1996, the ACL, as mentioned earlier, placed a home page on the Internet, which can

be accessed on the World Wide Web by the address:

www.cmt.anl.gov/acl/acl.htm

This page is well done and contains a lot of information about the organization, as well as a color picture of the staff members.

The following is a selected list of the activities of the ACL in the 1990s; many of these relate to other CMT programs that were described earlier. This list gives a good sense of the wide range of ACL capabilities.

Engineering Studies of Pyrochemical Processes for Integral Fast Reactor Fuels
 Rare-Earth Characterization Studies
 Zeolite Immobilization of IFR Waste Salt
 Studies of Alkalies in Hot Off-Gas from Pressurized Fluid-Bed Combustors
 Analysis of Environmental Samples
 Isolation of Strontium from Geological Samples for Isotopic Analysis
 Plutonium Residue Recovery Program
 Decomposition Products from Thermally Unstable Complexants
 Molten Corium-Concrete Interaction Studies
 Preparation of Samples for the National Energy Agency Committee on Reactor Physics Study
 JANUS Water Analysis
 Plutonium (VI) Speciation Study
 Analysis of Cotton and Waters
 ANL-West Soils, Vegetations, and Waters
 Radiation Damage Studies for Superconductive Super Collider Detector Research
 Synchrotron Thrust Group Activities
 Radiological Environmental Analyses for Rocky Flats Plant
 Analysis of Cores from Pressure Vessel of Experimental Boiling Water Reactor
 Analytical Support Using X-Ray Diffraction and Scanning Electron Microscopy
 Fourier Transform Infrared Microscopic Analysis of Fluid Inclusions
 Studies of Organic Fluid Fouling in Heat Exchange Systems
 Fourier Transform Infrared (FTIR) Analysis of Semivolatiles in Soils
 Remote Detection of Chemical Agents with FTIR
 Incinerator Monitoring for Organic Analytes
 Determination of Volatile Organic Compounds for Lake Michigan Study
 Walter Reed Army Institute of Research Site Characterization
 Method Development and Testing for EPA
 High Performance Liquid Chromatography Separation of Explosive and Other High Molecular Weight Compounds
 Supercritical Fluid Chromatography/Matrix Isolation-Infrared Spectroscopy
 Competitive Exchange Experiments in IFR Chemical and Engineering Support Studies
 X-Ray Diffraction Studies of Zeolite Materials
 Phase Composition/Solubility Studies on Equilibrated Mixtures of LiCl and KCl in Water
 Procedures for Determining Uranium and Uranium Isotopes in High Silica Soils
 Battery Program Support

Analysis of a Novel Neutron Absorber
Study of N₂O Emissions from Fluidized Bed Combustors
Environmental Monitoring Program
National Acid Precipitation Assessment Program
ANL Geoscience Programs
Radium Measurements (Geochemical)
Rocky Flats Environmental Restoration Program
Radiochemical Analysis of Experimental Boiling Water Reactor Vessel
Detection of Illegal Drug Laboratories
Computer Generation of Reporting Forms for Volatile Organic and PCB/Pesticide Environmental Analysis
Analysis of Waste Isolation Pilot Plant (WIPP) Samples by the Solid Adsorbent Method
Analytical Method Development for WIPP
Canister Cleaning and Certification for the WIPP
Analysis of Headspace Gases for the WIPP
Supercritical Fluid Extraction/Gas Chromatography for Analysis of Organic Compounds
Analysis of Environmental Samples for the U.S. Department of Agriculture
Environmental Assessment Study for Contaminants at Hohenfel Training Area Site, Germany
Development of Infrared Aerosol Analyzer
Support for CMT Nuclear Waste Programs
Monitoring of Antimony Levels in Scrap Aluminum
Chemical Transformation of Isotopically Enriched Tin Oxide
Advanced Photon Source Component Materials
Grafenwöhr Soil Samples
Stability of Calibration Standards for ICP/AES
Radiochemical Method Evaluation and New Method Development
Applications of FTIR Microscope to Identification of Wastes, Spill Residues, and Contaminants
Characterization of Products from Automobile Shredder "Fluff" Recycling
Determination of Rare Earth Elements and Calcium in Autopsy Tissues
Determination of Platinum in Tissues
Determination of ²²⁶Ra in Human Tissues
Isolation of Uranium and Thorium from Soils for Isotopic Analysis
Characterization of Nitrogen in Lime-Scrubber Waste
Properties of High-Temperature Superconductors
Identification of Hazardous Wastes
Development of Integrated Performance Evaluation Program
Determination of Americium in Environmental Samples
Rietveld Analysis of X-Ray Powder Diffraction Data
Stand-Off (Remote) Detection
Analytical Certification of IFR Special Reference Materials
Incinerator Monitoring
X-Ray Diffraction Support (ANL Programs)
Studies of TRU-Spec and RE-Spec Chromatography
Improved Methods to Determine Actinides in Environmental Samples
Animal Orphan Waste
Methodology for Characterizing Chlorofluorocarbons in Polyurethane Foam
Analysis of Nuclear Waste Glasses and Slags
Calcium Isotopic Determination in Canine Bone and Blood Serum
Automated Real-Time Analysis of Chemical Sensor Data

Analysis of Soils for Explosives
 Treatment of Cesium-Contaminated Milk
 Engineering Studies of Electrometallurgical Treatment of Nuclear Fuel
 Thermal Treatment Systems for Organic Effluents
 Characterization of Used HEPA Filters for Disposal
 Development of "Smart" Chemical Sensors
 Analytical Procedures for Waste Minimization and Pollution Prevention
 Gross α/β Analysis of Environmental and Mixed-Waste Samples
 Microwave-Assisted Extraction of Semivolatile Organic Compounds from Soil
 Analysis of Highly Acidic Mixed Waste
 Determination of Arsenic Species in Soil Samples from the Rocky Mountain Arsenal
 Transition Metal Speciation in Textile Mill Wastewater
 Determination of Uranium in Dissolver Solutions for Production of ^{99}Mo
 Development of an Analytical Scheme to Determine Actinides in Soil
 Methods for Determining Metals in Waste Oil
 Support for High-Temperature Superconductor Development
 Wastewater Treatability Studies
 Measurement of Calcium Isotopic Ratios in Canine Blood Serum
 Development of a Continuous Emission Monitor for Thermal Treatment Systems
 Determination of Platinum in Inner-Ear Fluid of Guinea Pigs
 Radon Remediation
 Separation of Mercury from Americium for Radioactive Waste Analysis
 Determination of Reaction Products from Molten Sodium and Chlorinated Hydrocarbons
 Dissolution Procedure for Low-Enriched Uranium Metal Targets
 Automated Target Recognition Using Multispectral Images
 Project in Support of Counternarcotics Efforts
 Development of Solid-Phase Extraction Disks for Radiochemical Analysis
 Analysis of Samples from Process to Recycle Aluminum Salt Cake
 Continuous Monitoring of Plasma Arc Furnace at ANL-West
 Preparation of Simulated Solidified Waste Samples for WIPP Performance Demonstration Program
 Automated Data Cataloging Procedure for Objects in AMPS Multispectral Imagery
 Development of Method for Radium Determination in Aqueous Samples
 Domestic Nuclear Smuggling Exercise
 Development of a No-Moving-Parts FTIR Sensor
 JANUS Reactor Characterization
 Study of Dry-Storage Casks for Spent Nuclear Fuel

THE DIVISION'S FUTURE

One certainty about the future is that the Division will continue to face fierce competition in seeking and keeping funding for programs. This competition comes from industry, the universities, other national laboratories, independent research organizations, and even other divisions at ANL. It is also affected by the changing perceptions of national technical needs and budget pressures

in Washington. The hope is that CMT will be able to meet this competition because of its excellent staff people, unique facilities, and extensive experience in a variety of research areas and technology development programs. In recent years, DOE funding of the Division's programs has declined, but much of the slack has been taken up by cooperative work with industries in the form of CRADAs (Cooperative Research and Development Agreements) and "work for others"

agreements, which may involve other Government agencies or private organizations.

With the demise of the Integral Fast Reactor program and the ban on commercial fuel processing in the United States, program support on processes for the recovery of uranium and plutonium from spent nuclear fuel has vanished. In its stead are programs to treat spent fuels to separate transuranic (TRU) elements (neptunium, plutonium, americium, and curium) for disposal in a waste depository. Electrometallurgical processes show promise for this application if current throughput rates can be increased. Preliminary results suggest that it may be possible to fix TRU elements on a zeolite bed in a waste form suitable for repository disposal.

For over ten years the Division has been conducting a variety of tests on simulated waste glasses and spent reactor fuels under conditions similar to those in the Yucca Mountain Repository. An exciting recent discovery is that even though neptunium, on release from a waste form, will migrate rapidly through the volcanic tuff of a repository, it will be retained by alteration products, principally zeolites, that form on the surface of the glass by reaction with water vapor. This finding must be explored further. In addition, continuation of long-term (5- to 10-year) corrosion tests with waste samples would be desirable.

Throughout its history, the Division has been at the forefront of development work on advanced solvent-extraction processes and equipment. An exciting new development is aqueous biphasic extraction, which shows promise for a wide range of applications. Typical examples are cleanup of industrial wastes and purification of low-grade ores such as bauxite for aluminum production. The Division intends to pursue this emerging technology vigorously because of its potentially great versatility.

The deregulation of electricity may bring about some major changes. Utilities are likely to reduce their involvement in the generation of electricity and concentrate on its distribution. Fuel cells operating on natural gas are expected to be finding increased use for local generation of electricity by cities, industrial organizations, office buildings, large housing complexes, and even homes. There is also much interest in the use of fuel cells in transportation applications, where they would most likely be used in hybrid vehicle systems. Competition will be heavy for funding to support research for these applications. The Division is well positioned to contribute to this effort due to its past work on molten carbonate and solid oxide fuel cells, and especially its leading-edge work in polymer-electrolyte fuel cells. The best opportunities for work on fuel cells may be where highly focused, sophisticated research efforts can be directed toward niche areas that need attention, rather than complete systems.

The situation with batteries is somewhat similar to that for fuel cells. The Division has had large programs on high-temperature lithium-alloy/metal sulfide batteries for electric vehicle propulsion and load leveling on electric utility systems. This technology was developed to the stage where it was ready for commercialization. The battery work evolved into a number of other areas, including sodium/metal chloride, lithium/polymer electrolyte, lithium-ion, and nickel/metal hydride systems. The lithium systems, in particular, have a potentially huge market in consumer electronics. Research in this field is highly competitive. The Division is enjoying considerable success in using sophisticated basic research tools to investigate the detailed chemistry and electrochemistry of these systems, and might have a similar role in other specialized areas of industrial research.

The Division has, for years, operated a large facility for conducting performance and cycle-life tests on a variety of commercial and experimental batteries. Diagnostic procedures for failure analysis or performance degradation are also conducted when needed. Indications are that similar testing of fuel cells may be a significant program

When the Division came into being in 1948, the staff consisted of many young scientists and engineers. Most if not all of these people have retired by now. The Division has been able to attract as

replacements outstanding young graduates and has also hired distinguished leaders in particular areas of research. In addition, the Division makes extensive use of postdoctoral people who are seeking R&D experience. Some of these are retained when their appointments expire. The Division takes very seriously its responsibility to train young scientists to do imaginative, high-quality research.

The consensus is that the future of the Chemical Technology Division can be viewed with cautious optimism.

FROM TEST TUBE TO PILOT PLANT

APPENDIXES

A 50 YEAR HISTORY OF THE CHEMICAL TECHNOLOGY DIVISION

General References

American Nuclear Society, *Controlled Nuclear Chain Reaction: The First 50 Years*, American Nuclear Society, LaGrange Park, IL (1992).

Clarfield, Gerald H., and William M. Wiecek, *Nuclear America, Military and Civilian Nuclear Power in the United States 1940-1980*, Harper & Row, New York (1984).

Evans, H., S. Vogler, and H. H. Hyman, *Studies in Counter-Current Solvent Extraction for the Decontamination of Enriched Uranium from the Proposed High Flux Research Pile*, ANL-4110, Argonne National Laboratory (Jan. 28, 1948).

Fermi, Laura, *Atoms in the Family; My Life with Enrico Fermi*, University of Chicago Press, Chicago, IL (1954).

Gillette, Robert, "Nuclear Safety (I): The Roots of Dissent," *Science* **177**, 771 (1972).

Gillette, Robert, "Nuclear Safety (II): The Years of Delay," *Science* **177**, 867 (1972).

Goldschmidt, Bertrand, *The Atomic Complex: A Worldwide Political History of Nuclear Energy*, American Nuclear Society, LaGrange Park, IL (1982).

Groueff, Stephane, *Manhattan Project: The Untold Story of the Making of the Atomic Bomb*, Little, Brown & Co., Boston (1967).

Hewlett, Richard G., and Oscar E. Anderson, Jr., *The New World, 1939-1946*, Pennsylvania State University Press, University Park, PA (1962).

Hewlett, Richard G., and Francis Duncan, *Atomic Shield, 1947/1952, Vol. II, History of the United States Atomic Energy Commission*, Pennsylvania State University Press, University Park, PA (1969).

Holl, Jack M., *Argonne National Laboratory, 1946-96*, University of Illinois Press, Urbana & Chicago, IL (1997).

Johnson, Otto (ed.), *1997 Information Please Almanac*, Houghton Mifflin Company, Boston (1997).

Massachusetts Institute of Technology Faculty, Jack Dennis (ed.), *The Nuclear Almanac—Confronting the Atom in War and Peace*, Addison-Wesley, Reading, MA (1984).

Orlans, Harold, *Contracting for Atoms*, Brookings Institution, Washington, DC (1967).

Rhodes, Richard, *The Making of the Atomic Bomb*, Simon & Schuster, New York (1986).

Seaborg, Glenn T., *The Plutonium Story: The Journals of Professor Glenn T. Seaborg, 1939-1946*, Ronald L. Kathren, Jerry B. Gough, and Gary T. Benedict, eds., Battelle Press, Columbus, OH (1994).

Smith, Alice K., *A Peril and a Hope: The Scientists' Movement in America 1945-1947*, University of Chicago Press, Chicago, IL (1965).

Smith, Alice K., and Charles Weiner (eds.), *Robert Oppenheimer: Letters and Recollections*, Harvard University Press, Cambridge, MA (1980).

Smyth, Henry D., *Atomic Energy for Military Purposes*, Princeton University Press, Princeton, NJ (1945).

United Nations, *Proceedings of the Second United Nations International Conference on the Peaceful Uses of Atomic Energy*, September 1-15, 1958, United Nations, Geneva, Switzerland (1958).

Wright, John W., *The New York Times 1998 Almanac*, Penguin Putnam Inc., New York (1998).

Acronyms and Definitions

A

ABS	Aqueous Biphasic Separation (process)
ACL	Analytical Chemistry Laboratory
ACS	American Chemical Society; American Ceramics Society
ACU	Advisory Committee on Uranium
ADF	Aqueous Dissolution Fluorination (process)
AEC	Atomic Energy Commission
AEM	Analytical Electron Microscopy
AES	Atomic Emission Spectrometry
AFBC	Atmospheric Pressure Fluidized Bed Combustion
AIChE	American Institute of Chemical Engineers
ALPR	Argonne Low Power Reactor
AMD	ANL Applied Mathematics Division
AMF	American Machine and Foundry
AMPEL	Argonne MHD Process Engineering Laboratory
AMPS	Apparatus for Monitoring and Purifying Sodium
ANL	Argonne National Laboratory
ANL-E	ANL-East (Illinois Site)
ANL-W	ANL-West (Idaho Site)
ANS	American Nuclear Society
APS	Advanced Photon Source
APST	Alkali Metal Particulate Sampling Train
ASR	Area Specific Resistance
ATR	Attenuated Total Internal Reflection (spectroscopy)
ATS	Alkali-Tin-Silicate Glass (for Pu)
AVIDAC	Argonne's Version of the Institute's Digital Automatic Computer

B

B&W	Babcock and Wilcox
-----	--------------------

BAPL	Bettis Atomic Power Laboratory
BASIC	A computer programming language
BBI	Breeder Blanket Interface
BCSC	Blanket Comparison and Selection Study
BET	Brunauer-Emmet-Teller (method of surface area analysis)
BNL	Brookhaven National Laboratory
BORAX	A series of ANL reactors used for safety research
BWR	Boiling Water Reactor

C

CAMD	Center for Advanced Microstructures and Designs
CANDU	Heavy water Canadian reactor
CCT	Coordinated Cluster Theory (for molecular structure)
CD-ROM	Compact Disk-Read Only Memory
CDC	Control Data Corporation
CDIF	Component Development and Integration Facility
CEN	ANL Chemical Engineering Division
CENHAM	A standardized glove-box design used in CMT
CFFF	Coal Fired Flow Facility
CHM	ANL Chemistry Division
Cintichem	Process used in Indonesia for ⁹⁹ Tc Recovery
CIS	Conformal Ionic Solution Theory
CMPO	Extractant used in TRUEX process
CMT	ANL Chemical Technology Division
COBOL	A business-oriented computer language
COMMIX	Computer code for liquid metal feed system
CORCON	Thermal hydraulic code for source-term packages
CP	Chicago Pile (several reactors)
CPC	Compound Parabolic Collector
CPM	Critical Path Method
CRADA	Cooperative Research and Development Agreement
CRBR	Clinch River Breeder Reactor

CREX	Solvent Extraction Process for Sr, Pb, Tc
CRSC	Center for Research on Sulfur in Coal (Illinois)
CRT	Cathode Ray Tube
CSDP	Continental Scientific Drilling Program
CSEX	Cesium Extraction Process
CSP	Chloride Silent Power (British battery manufacturer)
CT	ANL Components Technology Division
CTF	Components Test Facility
CTIF	Components Test and Integration Facility
CTIU	Component and Test Integration Unit
CTR	Controlled Thermal Reactor (program)

D

DADAC	Dosimetry And Damage Analysis Center
DARPA	Defense Advanced Research Projects Agency
DEC	Digital Equipment Corporation
DIGICALC	A computer program language
DOE	Department of Energy
DRIFTS	Diffusion Reflectance Infrared Fourier Transfer Spectroscopy
DTA	Differential Thermal Analysis
DTRAM	Dynamic Tritium Release and Analysis Model
DWPP	Defense Waste Processing Plant

E

EADL	Electrochemical Analysis and Diagnostics Laboratory
EBR	Experimental Breeder Reactor
EBR-I	Experimental Breeder Reactor No. I
EBR-II	Experimental Breeder Reactor No. II
EBWR	Experimental Boiling Water Reactor
ECN	Netherlands Research Foundation

ED	Electron Diffraction
EDAX	Energy Dispersive X-ray Analysis
EDS	Energy-Dispersive Spectroscopy (X-ray)
EDTA	Ethylene Diamine Tetraacetic Acid
EELS	Electron Energy Loss Spectroscopy
EES	ANL Energy and Environmental Sciences Division
EIA	Electrochemical Industrial Associates
EIS	ANL Environmental Impact Studies Division
EMF	Electromotive Force
ENG	ANL Engineering Division
EPA	Environmental Protection Agency
EPRI	Electric Power Research Institute
ERC	Energy Research Corp.
ERDA	Energy Research and Development Administration

EROSION/

MOD	Computer Code for Erosion in FBC
ES	ANL Energy Systems Division
ET	ANL Energy Technology Division
ESCA	Electron Spectroscopy for Chemical Analysis
ETF	Engineering Test Facility (MHD)
EXAFS	Extended X-ray Absorption Fine Structure

F

FACT	Facility for the Analysis of Chemical Thermodynamics
FARET	Fast Reactor Test Facility
FBC	Fluidized Bed Combustion
FCF	Fuel Cycle Facility (at ANL-W)
FE	ANL Fuels and Energy Division
FEF	Fuel Examination Facility (at ANL-W)
FEUL	Fossil Energy Users' Laboratory
FFTF	Fast Flux Test Facility
FLUFIX/	
MOD2	Computer Code for Fluidized Bed Hydrodynamics
FORTTRAN	A computer language
FTIR	Fourier Transform Infrared (spectroscopy)

FWDC Foster Wheeler Development Corp.
FY Government Fiscal Year

G

GAC General Advisory Committee
GC Gas Chromatography
GCFR Gas-Cooled Fast Reactor
GE General Electric Co.
GPU General Public Utilities Corp.
GTM Generic TRUEX Model

H

HDPE High Density Polyethylene
HEDL Hanford Engineering Development Laboratory
HEPA High Efficiency Particulate Air (filter)
HETP Height Equivalent to a Theoretical Plate (or stage)
HEU High Enriched Uranium
HFEF Hot Fuel Examination Facility
HFIR High Flux Isotope Reactor
HPLC High Performance Liquid Chromatography
HSRC Hazardous Substance Research Center
HTER High Throughput Electrefiner
HTGR High Temperature Gas-Cooled Reactor
HTM Hydrogen Titration Method
HWR-NPR Heavy Water Reactor-NPR (see NPR)

I

IAEA International Atomic Energy Authority
IBM International Business Machines
ICCI Illinois Clean Coal Institute
ICBM Intercontinental Ballistic Missile
ICPP Idaho Chemical Processing Plant
IEA International Energy Agency
IFC International Fuel Cells
IFR Integral Fast Reactor

ILRR Interlaboratory Reaction Rate (program)
INEEL Idaho National Engineering and Environmental Laboratory
INEL Idaho National Engineering Laboratory (now INEEL)
INOR International Tokamak Reactor
IPMA Ion Probe Microanalyzer
IPNS Intense Pulsed Neutron Source
IR Infrared
IR-100 Award by *Industrial Research Magazine*
IRMS Isotopic Ratio Mass Spectrometry
ISOA Intermediate State of the Art
ITER International Thermonuclear Experimental Reactor

J

JAERI Japan Atomic Energy Institute
JANAF Joint Army-Navy-Air Force (thermodynamic reference tables)
JANUS Reactor used at ANL for biological research
JCAE Joint Committee on Atomic Energy
JPDR Japan Power Demonstration Reactor

K

KAPL Knolls Atomic Power Laboratory
KB Kilobyte
KGB Komitet Gosudarstvennyy Bezopasnoski (Committee for State Security)

L

LAMPF Los Alamos Meson Physics Facility
LAMPRE Los Alamos Molten Plutonium Reactor Experiment
LANL Los Alamos National Laboratory
LASL Los Alamos Scientific Laboratory (now LANL)
LBL Lawrence Berkeley National Laboratory
LEU Low Enriched Uranium

LIPE	Lithium-Polymer Electrolyte (battery)
LITCO	Lockheed Idaho Technology Co.
LLNL	Lawrence Livermore National Laboratory
LM	Lanthanum Manganite (fuel cell cathode)
LMFBR	Liquid Metal Fast Breeder Reactor
LMFR	Liquid Metal Fuel Reactor
LMFT	Low-Mass Flow Train (at Coal Fired Test Facility)
LOFT	Loss Of Fluid Test
LPTL	Lithium Processing Test Loop
LSU	Louisiana State University
LWR	Light Water Reactor

M

MAP3S	Multistate Atmospheric Power Production Pollution Study
MASCOT	Computer code used for sodium trap design
MASS-11	A word-processing program
MAWS	Minimum Additive Waste Stabilization Program
MBO	Management By Objectives
MCCI	Molten Core-Concrete Interaction
MCFC	Molten Carbonate Fuel Cell
MCPU	Multiple Cycle Plutonium Utilization
MCT	ANL Materials and Components Technology Division
MD	Molecular Dynamics
MEDEC	Melt/Drain Evaporation Calcination Process
MERDC	Mobility Equipment Research and Development Command
MET	ANL Metallurgy Division (now SSS, MST and others)
METC	Morgantown Energy Technology Center
MeV	Million Electron Volts
MFTF	Mirror Fusion Test Reactor
MHD	Magnetohydrodynamics
MI	Matrix Isolation (spectrometry)
MIR	Russian Space Station
MISTT	Midwest Interstate Sulfur Transport and Transformation

MIT	Massachusetts Institute of Technology
MMS	Masked Multichannel Scaler
MNDO	Modified Neglect of Differential Overlap (molecular structure theory)
MNM	Metal-to-Nonmetal (transitions)
MOX	Mixed Uranium-Plutonium Oxide (reactor fuels)
MS	Mass Spectrometry
MS-DOS	Microsoft Disk Operating System
MSD	ANL Materials Science Division
MSID	Mass Spectrometric Isotopic Dilution
MSOFC	Monolithic Solid Oxide Fuel Cell
MSRE	Molten Salt Reactor Experiment (at ORNL)
MST	ANL Materials Science and Technology Division
MSW	Municipal Solid Waste
MTR	Materials Test Reactor
MTU	Mass Transfer Unit (in electrolyzer)
MW(e)	Megawatts Electrical (electricity produced by a reactor)
MW(t)	Megawatts Thermal (heat produced by a reactor)

N

N.S.	Nuclear Powered Ship (civilian)
NAA	Neutron Activation Analysis
NAPAP	National Acid Precipitation Assessment Program
NAS	National Academy of Sciences
NASA	National Aeronautics and Space Administration
NASICON	An experimental ionically conductive glass composition
NBL	New Brunswick Laboratory
NBS	National Bureau of Standards
NBTL	National Battery Test Laboratory
NDRC	National Defense Research Council
NEACRP	National Energy Agency Committee on Reactor Physics
NEPA	Nuclear Energy for Propulsion of Aircraft

NEPEX	Neptunium-Plutonium Extraction Process
NKVD	Predecessor of KGB (see)
NMFECC	National Magnetic Fusion Energy Computation Center
NMR	Nuclear Magnetic Resonance
NO _x	Generic term for nitrogen oxides, usually applied to air quality
NPR	New Production Reactor (for tritium production)
NPS	National Park Service
NRC	Nuclear Regulatory Commission
NRTS	National Reactor Testing Station (now INEEL)
NRX	Reactor at Chalk River, Canada
NSLS	National Synchrotron Light Source (at BNL)
NTA	Nitrilotriacetic Acid

O

O/M Ratio	Oxygen-to-Metal Ratio
OEPM	Office of Electrochemical Project Management
OPEC	Organization of Petroleum Exporting Countries
ORACLE	Oak Ridge Automatic Computer Logical Engine
ORNL	Oak Ridge National Laboratory
ORR	Oak Ridge Research Reactor
OSRD	Office of Scientific Research and Development

P

PAD	ANL Particle Accelerator Division
PAFC	Phosphoric Acid Fuel Cell
PAH	Polycyclic Aromatic Hydrocarbons
PAHR	Post-Accident Heat Removal
PASCAL	A computer language
PC	Personal Computer
PCB	Polychlorinated Biphenyl
PDP	Model of Digital Equipment Corp. computer
PEFC	Polymer Electrolyte Fuel Cell

PEG	Polyethylene Glycol
PEMFC	Polymer Exchange Membrane Fuel Cell
PEO	Polyethylene Oxide
PERT	Program Evaluation and Review Technique
PFBC	Pressurized Fluidized Bed Combustion
PFP	Plutonium Finishing Plant
PIFAG	Production Irradiated Fuel Assay Gauge
PL/1	A computer language
PNL	Pacific Northwest Laboratory
POB	Proof of Breeding
PPG	Polypropylene Glycol
PRDC	Power Reactor Development Corporation
PuRR	Plutonium Residue Recovery
PVC	Polyvinyl Chloride
PWR	Pressurized Water Reactor
PYRO	Computer Model for IFR Process

Q

QA	Quality Assurance; ANL Quality Assurance Division
Quad	One quadrillion (10 ¹⁵) Btu

R

RABSAM	Regenerable Activated Bauxite Sorber Alkali Monitor
RAM	Random Access Memory
RAS	ANL Reactor Analysis and Safety Division
RBMK	Pressurized water reactor of Russian design
RDF	Refuse Derived Fuel
RDT	Reactor Development and Technology (an AEC division)
RE	ANL Reactor Engineering Division; Rare Earths
RERTR	Reduced Enrichment for Research and Test Reactors
RFP	Rocky Flats Plant
RMC	Reverse Monte Carlo
ROM	Read Only Memory

RTNS Rotating Target Neutron Source

SSACRD Safety Analysis Computerized
Reactor DataSAFT Societe des Accumulateurs Fixe et
de TractionSASPE Algorithm for Speciation and
Partitioning EquilibriaSASSE Algorithm for Stagewise Solvent
ExtractionSCAQMD California South Coast Air Quality
ManagementSCTI Sodium Components Test
Installation

SEM Scanning Electron Microscopy

SEM/EDS Scanning Electron Microscopy/
Energy Dispersive Spectrometry

SERI Solar Energy Research Institute

SFC Supercritical Fluid
ChromatographySIBELIUS Joint CMT-European Study of
Ceramic Fusion Breeder
Blankets

SIR Sodium Intermediate Reactor

Site A Site of CP-2 in Argonne Woods of
Palos Park Forest PreserveSite D Current Location of ANL in
DuPage County

Site W Hanford, Washington

Site X Oak Ridge, Tennessee

Site Y Hanford, Washington

SNAP Systems for Nuclear Auxiliary
Power (in space satellites)

SNL Sandia National Laboratories

SNM Special Nuclear Materials

SOFC Solid Oxide Fuel Cell

SOLGASMIX

Computer code for calculating
equilibrium gas compositionsSPACE Worksheet calculation for plant
equipment size, plant space,
costsSPECTER Computer code for radiation
damage

SPM ANL Special Materials Division

SPR Single-Pass Reactor

SREX Strontium Extraction Process

SRL Savannah River Laboratory (now
SRNL)SRNL Savannah River National
Laboratory

SRP Savannah River Plant

SRTALK ORNL-PNL Solvent Extraction
Process for Sr, Tc, Cs extraction

SS Stainless Steel

SSC Superconducting Super Collider

SSS ANL Solid State Science Division

SSTR Solid State Track Recorder

STA Special Term Appointment

STARFIRE A commercial fusion reactor
concept (ANL)

STEP Source Term Experiments Program

STR Submarine Thermal Reactor

T

TBP Tributyl Phosphate

TCA 1,1,1-Trichloroethylene

TCE Trichloroethylene

TD ANL Technology Development
Division

TEM Transmission Electron Microscopy

TEPR Tokamak Experimental Power
ReactorT_EX A word processing computer
program

TGA Thermogravimetric Analysis

THORP Thermal Oxide Reprocessing Plant

TMI Three Mile Island

TNS The Next Step (a nuclear fusion
reactor concept)TPD Temperature Programmed
Desorption

TREAT Transient Reactor Test Facility

TRIO Tritium Recovery In Pile

TRU Transuranium or transuranic

TRUEX Transuranium Extraction (process)

TSTA Tritium Systems Test Assembly

TVA Tennessee Valley Authority

U

UCLA	University of California at Los Angeles
UI-UC	University of Illinois at Urbana-Champaign
USABC	United States Advanced Battery Consortium
U.S.S.	U. S. Navy Ship
U.S.S.R.	Union of Soviet Socialist Republics
UKAEA	United Kingdom Atomic Energy Authority
UTC	United Technologies Corp.

V

VAX	Model of Digital Equipment Corp. computer
VRLA	Valve-Regulated Lead-Acid (battery)

W

WIPP	Waste Isolation Pilot Plant
WRAIR	Walter Reed Army Institute of Research
WSRC	Westinghouse Savannah River Co. (type of glass)
WVDP	West Valley Demonstration Plant (type of glass)
WWII	World War II

X

X-10	Clinton Laboratory at Oak Ridge
XANES	X-ray Absorption Near-Edge Spectroscopy
XRD	X-Ray Diffraction
XSW	X-ray Standing Waves

Y

Y-12	Isotope Separations Plant at Oak Ridge
YSZ	Yttria-Stabilized Zirconia (fuel-cell electrolyte)

Z

ZGS	Zero Gradient Synchrotron
ZPPR	Zero Power Plutonium Reactor
ZPR	Zero Power Reactor
ZSM-5	Type of zeolite

Subject Guide

1940-1950: THE BEGINNING.....	1
The Manhattan Project	1
The Atomic Energy Commission and the National Laboratories.....	7
The Met Lab	8
The Chemical Engineering Division.....	16
1950-1960: THE NUCLEAR PROMISE	23
The National and International Scene.....	23
Reactors	26
The Move to Site D.....	29
New Employees	31
Services	34
Tools of the Trade.....	37
The New Buildings	39
Building D-205	39
Building D-310	46
Division Organization and Management	47
Technical Programs	50
Aqueous Processes.....	50
Determination of Breeding Gain in EBR-I.....	50
The Halex Process	51
Aqueous Processing of Alloy Fuels	53
Contactor Development.....	53
Pyrometallurgical Processes.....	54
Pyrometallurgical Research	54
Pyrometallurgical Process Development.....	56
The EBR-II Fuel Cycle Facility (FCF).....	62
Fluoride Volatility Processes.....	65
Feed Materials Processing.....	71
Conversion of Uranyl Nitrate Solution to Uranium Oxide.....	71
Production of Refined Uranium Hexafluoride.....	72
Waste Treatment	75
Incineration of Radioactive Solid Wastes.....	75
Fluidized Bed Calcination of Aqueous Wastes.....	76

Ion-Exchange Studies	77
Gamma Irradiation Facility	78
The "Hot Rock"	79
Fluidized Bed Technology	80
Reactor Safety	81
Metal-Air Reactions	81
Metal-Water Reactions	81
Calorimetry	82
The Analytical Chemistry Laboratory	83
Analytical Research and Nuclear Constant Measurements	85
Especially Significant Publications	86
 1960-1970: TURBULENT TIMES	 89
The Domestic and International Climate	89
Reactors	92
The Division	92
Management	96
Building Addition	98
Tools of the Trade	99
CENHAM Glove Boxes	101
Technical Programs	102
EBR-II Fuel Cycle Facility	102
Pyrochemical Process Development	106
Chemistry of Liquid Metals	108
Fluoride Volatility Processes	112
Laboratory Investigations	112
Process Development	114
Physical and Thermodynamic Properties of High Temperature Materials	121
Reactor Safety	123
Metal Oxidation and Ignition Kinetics	123
Metal-Water Reactions	124
Fast Reactor Safety Studies	124
Chemistry of Irradiated Fuels	125
Preparation of Fast Reactor Fuels	125
Preparation of High-Purity Plutonium-238 Metal	127
Determination of Nuclear Constants	127
Calorimetry	128

Energy Conversion and Storage.....	130
Thermoelectric Research	130
Thermally Regenerative Galvanic Cells.....	131
Lithium-Chalcogen Batteries	133
Fluidized Bed Combustion of Coal	134
Analytical Chemistry.....	135
Waste Processing and Gamma-Irradiation Facility	137
Studies and Evaluations.....	137
1970-1980: TRANSITIONS	139
The National Scene	140
Nuclear Power	140
The Laboratory	145
The Division	146
General Information	146
Division Administration	151
Personnel	152
Procurement.....	153
Budget Management	154
Building Facilities and Services.....	154
Computers.....	155
Miscellany	158
Technical Programs	160
Lithium/Metal Sulfide Batteries	160
Introduction.....	160
Industrial Participants, Consultants, and Contractors	161
Exploratory Studies	162
Materials Research and Development.....	165
Cell Development.....	167
"Status Cells"	168
Batteries	169
Personnel.....	171
Development of Aqueous Batteries for Electric Vehicles.....	172
Industrial Contractors' Programs	173
ANL Supporting Research.....	174
Fuel Cells.....	176
Electrolytic Generation of Oxygen for Space Applications	176

Aqueous Electrolytes for Hydrocarbon Fuel Cells	177
Molten Carbonate Fuel Cells	177
Coal Combustion.....	178
Introduction.....	178
Classes of Coal.....	180
Fluidized Bed Combustion of Coal.....	180
Fossil Fuel Utilization and Conversion	187
Magnetohydrodynamics	188
Personnel.....	189
Sodium Technology	191
Analytical Standards Program	192
National Meter Program	192
Steam Generator Leak Detection	195
Post-1974 Sodium Technology Program.....	196
Design and Regeneration of Cold Traps.....	197
Bulk Sodium Processing.....	198
Personnel.....	199
Fuel Element Failure Detection	199
Solar Energy	199
Fuel-Cycle Studies	202
Development of Advanced Fuel Recovery Operations.....	203
Post-1973 Fuel-Cycle Programs	206
Nuclear Fusion Energy Research.....	209
Lithium Hydride Systems	210
Lithium Blanket Processing.....	213
Neutron Dosimetry	214
Tritium Handling and Containment Studies	216
Materials Chemistry and Thermodynamics.....	217
Calorimetry	217
High-Temperature Thermodynamic Studies	218
Reactor Fuel Studies.....	219
Irradiated Mixed Oxide Fuels	222
Molten Salt Chemistry	225
Phase Equilibria	226
Molten Salt Spectroscopy	227
Theoretical Studies	228
Liquid Metal Chemistry	229

Other Basic Research	230
Nucleation Studies.....	230
Meteoritic Studies	230
Thermal Conductivity of Associating Gases	231
Fluid Catalysis.....	232
Environmental Chemistry.....	232
Analytical Chemistry Laboratory	234
Nuclear Safeguards	234
1980-1990: CMT—NEW NAME, NEW MISSIONS.....	237
National Affairs	238
The Nuclear Industry	241
The Division	241
Technical Programs	249
Lithium-Alloy/Iron Sulfide Batteries.....	249
Electrode Chemistry	250
Materials Engineering	252
Cell Development.....	253
Cell Testing.....	256
Modules, Batteries, and Auxiliary Components	257
Personnel.....	259
Other High-Temperature Battery Research.....	260
Sodium/Sulfur Batteries	260
Glass Electrolyte Systems.....	261
Composite Solid Electrolyte Systems	262
Alternative Cell Systems	262
Aqueous Battery Research and Development	264
Development of Electric-Vehicle Batteries by Contractors	264
National Battery Test Laboratory (NBTL)	265
Supporting Battery Research	266
Other Battery Applications	267
Industrial Electrochemical Technology.....	268
Personnel.....	268
Fuel Cells.....	269
Molten Carbonate Fuel Cells	269
Solid Oxide Fuel Cells.....	271
Personnel.....	274

Coal Utilization.....	274
Argonne Premium Coal Sample Program	274
Separation of Coal Macerals.....	275
Fluidized-Bed Combustion of Coal.....	275
Cleanup of Hot Gases from Pressurized Fluidized-Bed Combustors	277
Management Activities.....	278
Personnel.....	279
Magnetohydrodynamic Heat and Seed Recovery Technology	279
Control of NO _x and SO _x Emissions.....	280
Fouling of Steam Generator Tubes in the Radiant Boiler	280
Follow-Up Applications of Feul	281
Recovery of Potassium Carbonate Seed Material	281
Supporting Studies	282
Personnel.....	282
Energy and Municipal Waste Technology	282
Energy from Municipal Waste.....	282
Hazardous Organic Wastes.....	283
Treatment/Disposal of Reactive Wastes.....	284
Solar Energy	284
Solar Collector Development.....	284
Ice Storage	285
Thermal Storage.....	286
Personnel.....	286
Desiccant Studies	286
Nuclear Fusion Energy Research.....	287
Systems Analysis Studies	287
Materials Research and Development.....	289
Solid Breeder Blankets	289
Aqueous Breeder Blanket	292
Dosimetry and Damage Analysis.....	292
“Cold Fusion”	294
Steel Research Initiative	294
Electromagnetic Casting of Steel	295
Steel Scrap Beneficiation.....	296
Sodium Technology	297
Optimization of Cold Trap Design.....	297
<i>In Situ</i> Regeneration of Cold Traps.....	299
Sodium Purification by Distillation.....	299
Sodium Waste Technology	300

Sodium-Concrete Reactions.....	301
Personnel.....	301
Nuclear Separations Technology	301
Analytical Support for LWBR Proof-of-Breeding.....	301
TRUEX Process Development.....	302
Recovery and Separation of Molybdenum-99	306
Integral Fast Reactor Electrometallurgical Process	307
The Integral Fast Reactor Concept.....	307
Process Flowsheet Development.....	308
Process Feasibility and Demonstration	308
Large-Scale Demonstration of Electrefining	310
IFR Waste Management	311
Personnel.....	312
Plutonium Residue Recovery (PuRR) Process	312
Nuclear Waste Management.....	314
Yucca Mountain Project	314
Analog Experiments for Proposed Hanford Repository.....	317
Brittle Fracture Studies of Solid Wastes.....	318
Nuclear Methods of Oil Well Logging.....	318
Personnel.....	318
Applied Physical Research	319
Oxide Reactor Fuels	319
Metallic Reactor Fuels.....	321
Fission-Product Behavior	323
Personnel.....	329
Basic Research.....	329
Homogeneous Catalysis	329
Thermodynamics.....	334
Thermochemistry	338
Electrochemistry	343
Other Spectroscopic and Structural Studies.....	346
Interfacial Chemistry	346
Special Basic Research Investigations	348
Solid Oxide Superconductors	351
Environmental Chemistry	352
Geochemistry of Thermal Systems	355
Analytical Chemistry Laboratory	357

1990-1998: INTO THE FUTURE.....	361
National Affairs	361
Energy and the Environment	363
The Laboratory	365
The Division	366
Organization	366
Personnel	368
In Retrospect	368
Technical Programs	371
Electrochemical Technology	371
Lithium Alloy/Metal Sulfide Batteries	371
Sodium/Metal Chloride Batteries.....	373
Other Advanced Batteries.....	375
Electrochemical Analysis and Diagnostics Laboratory.....	378
Fuel Cell Research and Development	381
Fossil Fuel Research	388
Fluidized-Bed Combustion Studies.....	388
Magnetohydrodynamic Studies.....	393
Hazardous and Mixed Waste Research	394
Modeling Studies.....	394
Microwave-Assisted Detoxification.....	395
Aqueous Biphase Processes.....	395
Electrokinetic Processes	399
Chemically Bonded Waste Forms.....	400
Radiolytic Gas-Generation Studies	401
Actinide Stability/Solubility Studies	401
Actinide Speciation in Groundwater	401
Office of Waste Management	403
Personnel.....	404
Nuclear Waste Management.....	404
Testing of High-Level Waste Glasses	404
Testing of Spent Fuel.....	408
Waste Isolation Pilot Plant Project.....	409
Vitrification of Low-Level Waste	409
Characterization of Contaminated Soils and Other Materials	410
Other Personnel	411
Separation Science and Technology	411
Development and Application of TRUEX Technology	412

Centrifugal Contactor Development	415
Recovery and Separation of Molybdenum-99	416
Miscellaneous Programs	418
Integral Fast Reactor Pyrochemical Process	419
Process Flowsheet and Chemistry Studies	419
Process Development Studies	420
Engineering-Scale Process Development	424
Waste Treatment Processes	425
Advanced IFR Flowsheet	428
Personnel	429
Electrometallurgical Treatment of Spent Reactor Fuels	429
Advanced Electrorefiner Concepts	430
Process Development Studies	431
Actinide Recovery from Spent Oxide Fuels	433
Treatment of Spent Oxide Fuels for Safe Disposal	437
Personnel	441
Fusion-Related Research	441
Desorption Measurements for $\text{LiAlO}_2\text{-H}_2\text{-H}_2\text{O(g)}$ System	441
Tritium Release Studies	442
Lithium Vaporization and Corrosion	443
Personnel	444
Applied Physical Chemistry	444
Physical Properties of Core-Concrete Mixtures	445
Support Studies for New Production Reactor (NPR)	446
Thermophysical Property Studies	448
Development of Synchrotron Analytical Capabilities	450
Basic Chemistry Research	450
Physical Organic Chemistry	450
High T_c Superconductors	455
Ordering and Association in Liquids	457
Quantum Chemical Studies	458
Molecular Sieve Research	460
Electrochemical and Corrosion Studies	461
Polymer Electrolytes	465
Geochemistry	465
Enhanced Metallurgical Processes	468
Analytical Chemistry Laboratory (ACL)	468
The Division's Future	471

APPENDIXES

General References	475
Acronyms and Definitions.....	477
Subject Guide	485
Name Index	495

Name Index

Aase, Scott 404, 412, 418
 Abraham, Bernard 20
 Abraham, Daniel 429
 Abrajano, Teofilo 319, 357, 408, 467
 Ackerman, John 82, 122, 159, 171, 177, 178, 191,
 246, 259, 268, 274, 312, 416, 419, 420, 429
 Ackerman, Ray 122
 Adams, Max 43, 71, 125, 192, 199
 Ader, Milton 19, 22, 30, 37, 43, 55, 130
 Agnew, *Spiro*¹ 140
 Agrawal, Rajiv 279
 Ahmed, Shabbir 284, 388
 Aikens, Alex 10, 20, 22
 Alamillo, Anita (Franchini) 369
 Alford, Kurt 368
 Alfredson, Peter 114
 Alkire, Richard 161
 Allen, John 133, 149, 171, 193, 199, 202, 286
 Allen, Theodore 35
 Althoetmar, James 111
 Ambrose, Lauren 246, 368, 369, 411
 Amine, Khalil 376, 377, 388
 Ammerpohl, Laurie (see Carbaugh)
 Anastasia, Louis 191
 Anderson, Doris (see Danielson)
 Anderson, Karl 55, 110, 111, 125, 171, 259
 Anderson, Margaret 246
 Andropov, Yuri 239
 Anker-Johnson, Betsy 151
 Anthers, David 84, 133
 Archart, Gregory 467
 Aristide, Jean Bertrand 362
 Armstrong, Don 124, 127
 Armstrong, Neil 91
 Arntzen, John 37, 108, 171, 259, 312, 329, 422, 429
 Arzate, Vanessa (see Mendez) 246, 359
 Asanovich, George 22
 Askew, Barry 161, 170
 Aznavoorian, Peter 359

Bacher, Robert 7
 Baerns, Manfred 121
 Bailey, Jody 369
 Bakel, Allen 401, 408-410, 467
 Baker, Louis 38, 82, 95, 100, 124
 Baker, Thomas 114
 Banacek, Steve 84, 133
 Banaszak, James 123, 404
 Bane, Ralph 148, 359
 Banks, Eunice 22, 52
 Barbosa, Lilia (Mojica) 246, 359, 369, 429
 Barghusen, John 124, 173, 268
 Barnes, Charles 124
 Barney, Duane 146, 161, 172, 243, 244, 246, 254,
 259
 Barr, Susan 37, 245
 Barrett, Norma 369, 411
 Barsky, Murray 137, 149, 192, 199
 Bartholme, Louis 171, 193, 195, 199, 259
 Basco, John 312, 404, 411, 416, 429
 Bates, John 228, 318, 404, 408-411
 Battaglia, Vincent 373, 376, 377
 Battles, James 94, 95, 97, 122, 159, 161, 163, 165,
 171, 244, 246, 257, 259, 294, 312, 361, 366, 367,
 404, 429
 Baudino, Gerald 359
 Baxman, Horace 22
 Bean, Charles 234
 Beatty, Dick 172
 Beck, Raymond 61
 Beck, Theodore 162
 Becker, Joseph 268
 Bednarick, Helen 22
 Beederman, Morris 20, 22
 Begin, Menachem 140
 Bell, Alexander 3
 Benedek, Roy 376
 Bennett, George 55, 61, 108, 159
 Bennion, Douglas 162, 172
 Benson, Roy 279, 302
 Bentson, Lloyd 238
 Beres, Karen 150
 Bergland, Paul 55
 Beria, Lavrenti 24
 Berkman, Michael 22

¹ Names of non-ANL personnel in italics.

- Bernstein, George 15, 19, 20, 22, 54, 63, 105, 125, 171, 205, 306, 312
- Berrill, Edward 160, 171, 268
- Bertoletti, Jacqueline 246
- Beskid, Nick 404
- Beyerlein, Robert 348
- Binelli, Maureen 136, 149
- Bingle, James 70, 81, 84, 124, 133, 159
- Binz, Carl* 355
- Birk, James* 161
- Birmingham, Alice 150, 246, 274, 359, 369
- Biwer, Richard 268, 408
- Blackburn, Paul 122, 147, 191, 217, 218, 274, 282, 329, 444
- Blaedel, Walter 22
- Blake, Natalie 306
- Blander, Marie-Louise (see Saboungi)
- Blander, Milton 158, 171, 227-230, 259, 279, 287, 296, 338, 351, 352, 450, 457-459, 468
- Blaskovitz, Robert 429
- Blomquist, Robert 199, 219, 220, 229, 292, 329, 338, 429, 450
- Bloom, Ira 259, 268, 334, 338, 346, 352, 373, 388, 457, 458
- Bloom, William 136, 149
- Bogusch, Eugene 149
- Bohlke, John 357
- Bohr, Niels* 1, 3
- Boland, James 124
- Boparai, Amrit 279, 284, 359, 468
- Böthe, Walter* 5
- Bouquist, James 171
- Bourne, Sidney 286
- Bowden, Marion 127
- Bowers, Delbert 291, 306, 312, 359, 403, 468
- Bowyer, Dale 191
- Box, Steven 171
- Boxberger, L. Michael 367, 368
- Boyd, Aaron 22
- Bozisch, Eugene 136
- Bradbury, Norris* 7
- Bradley, Charles 408
- Brady, James* 238
- Breeden, John 20, 22
- Bresee, James 22
- Brewer, Kenneth 78
- Breyne, Ronald 70, 151, 152, 159, 243, 245, 246, 367
- Brezhnev, Leonid* 239
- Briggs, Lyman* 2
- Bringle, Joyce 369
- Brock, Ronald 191, 302
- Brown, Alan 259, 268, 274, 279, 284, 346, 352, 388, 457
- Brown, Harrison* 21
- Brown, Herbert 20, 22, 47, 51, 76, 99, 101, 149, 151, 152, 154, 158, 160, 243, 245, 246
- Brown, Norma (Pinches) 22, 158
- Brown, Philip 155
- Brun, Torben 348
- Buck, Edgar 401, 408-411
- Buckner, Leila (see Settle)
- Bukowski, Marlene 246, 269, 274
- Bullinger, C. 76
- Bump, Thomas 191
- Burke, Mary 246, 369
- Burkel, Louis 268
- Burnett, L. 191
- Burris, Leslie 17-20, 22, 31, 51, 52, 57, 61, 87, 93, 106, 139, 146, 147, 149, 159, 192, 199, 237, 243, 244, 246, 307, 312
- Bush, Barbara* 362
- Bush, George* 237-239, 361, 362, 365
- Bush, Vannevar* 2
- Bussey, Susan 359
- Butler, Jerry 369
- Butschelder, Arthur 22
- Butz, Susan 150
- Buzzelli, Ed* 162
- Byers, Charles 319
- Bykowski, Susan (see Rura)
- Byrne, Kevin 388, 404
- Cafasso, Fred 93, 111, 147, 191-193, 199, 227, 243, 244, 246, 287, 301, 329
- Cahan, Boris* 162
- Cairns, Elton 93, 95, 112, 133, 134, 147, 161, 164, 172, 369
- Calaway, Wallis 216, 292, 352, 465, 467
- Canaday, Patricia (Wood) 150
- Cannon, Thomas 61, 108, 127, 191, 302
- Carbaugh, Laurie (Malak, Ammerpohl) 246, 369

- Carls, Erwin 135, 153, 180, 183, 279, 312, 392, 422, 425, 429
Carlson, Chester 100
 Carlson, Neill 102
 Carothers, Earl 268
 Carothers, Janet (Stratton) 247, 369, 429, 444
 Carter, David 388
Carter, Jimmy 139, 140, 144, 237-239
 Cassulo, John 124, 134
 Caster, Jack 22
 Cescato, Loretta 246, 369
 Chaiko, David 306, 342, 399, 412
 Chamberlain, David 306, 404, 409-412, 416
Chambers, Whittaker 24
 Chandrasekharaiah, Malleseety 121
 Chang, Yoon 365
 Chaplin, Ann 150
 Chapman, Glen 156, 171, 248, 368
 Chapman, Stefanie 246
 Chasanov, Martin 95, 110, 124, 127, 219, 220, 329
 Che, Stanley 191, 292
 Cheek, Diane 369
 Chellew, Norman 22, 43, 55, 96, 125, 199, 216, 292
 Chen, Horng-Yih 123
 Chen, Michael 334, 411, 455
 Chen, Tsewei 191
 Chen, Yat-Ching 338
Chernenko, Konstantin 239
 Chiarello, Ronald 467
 Chilenskaskas, Albert 63, 105, 115, 159, 161, 168, 169, 171, 259, 268, 373
 Cho, Dae 124
 Chow, Lorac 306, 412, 416, 426, 429
 Christianson, Clinton 173, 259, 268
 Cissel, Donald 194
 Claar, Terry 274
 Clark, Mark 411
 Clark, Sharon 37
 Clark, Teresa 246
 Clemens, Martin 279, 404
 Clemmer, Robert 216, 289, 291, 292, 294, 444, 447
 Clifton, Carol 122
Clinton, William 361, 362, 365
 Cohen, Stanley 100
 Cole, Brandon 381
Cole, Terry 162
 Coleman, Lester 15, 17, 19, 20, 22, 30, 51, 63, 96, 105, 125, 147, 152, 199
 Colunga, Maria 246
Comey, David 92
Compton, Arthur 2, 3, 9
Conant, James 2, 3, 7
 Conner, Clifford 241, 306, 404, 410, 411, 416, 418
Consiglio, Joseph 264
 Contos, Maria (Scaropoulos) 37, 149, 245, 246, 368, 369
 Cook, Glenn 141, 142, 173, 268, 274
 Cooper, Thomas 141, 171
 Cople, Jacqueline (Leddin) 248, 306, 368, 412
 Corp, David 268
 Couture, Rex 317, 319
 Cramer, Thomas 37
 Creamer, Edward 268
 Crewe, Albert 93, 94, 110, 111
 Crouthamel, Carl 38, 51, 83, 85-87, 93, 95, 112, 125, 128, 131, 133, 136, 147, 156, 369
 Crudup, Valerie 246
 Cunnane, James 394, 401, 403, 404, 408-411
 Cunningham, Paul 82, 148, 149, 171, 226, 228, 232, 355, 357
 Curtiss, Larry 292, 334, 338, 342, 343, 348, 352, 370, 444, 450, 457-459, 461, 465
 Cushing, Beatrice (Hjelte) 84, 158
 Cushing, Carl 158

Dangerfield, Rodney 240
 Danielson, Doris (Anderson) 158
 Danielson, Philip 121, 122, 131, 158, 218
 Davis, Kathleen 112, 133
 Deeken, Philip 302
 Deerwester, Marshall 82, 124
 Dees, Dennis 274, 294, 346, 373, 376, 388
 DeGrande, Virginia 22, 40
 DeKany, John 61
 Deloria, Nancy 246
 DeLuca, William 171, 173, 260, 268, 381
 Demirgian, Jack 284, 286, 359, 394, 411
Dempster, Arthur 3
 Denst, Thomas 36, 155
 DeNuccio, Dennis 171
 Deutsch, Lee 22, 84
 Devgun, Jas 404

- Devine, Barry 22
 Dewell, Edgar 128
 Dewey, Gerald 429
 Deziehl, Chester 22
 Dhar, Sanat 111, 199
 Dillon, Ira 20, 22, 51, 57, 79, 87, 111, 159
 DiSanto, Tom 411
 Dokmanovic, Branko 94
Dole, Robert 361
 Donnely, Wendy (see Lamb)
 Doolin, Patrick 155, 160
 Dorsey, Lester 20, 22, 51, 61, 151, 154
 Dosi, Rajiv 388
 Drabek, Vera 136, 149
 Draley, Joseph 147, 192, 199
 Drapcho, David 355
 Driskell, Marie 22, 37, 149
DuBridge, Lee 7
 Dudey, Norman 128, 147, 148
 Duffield, Robert 42, 93, 145
Dukakis, Michael 237, 238
Dunning, John 162
 Duoba, Michael 260
 Dusek, John 171
 DuTemple, Octave 49, 70
 Dyrkacz, Gary 279
- Eastman, Dean 361, 366
 Eberhart, James 111, 159, 171, 199, 230
 Ebersole, Earl 103
 Ebert, William 319, 404, 408, 410
 Eckels, Thomas 63, 105
Edison, Thomas 264
 Edwards, Harry 125, 192, 199
 Edwards, Russell 95, 121-123, 130, 131
 Eident, Paul 152
Einstein, Albert 2
 Einziger, Robert 404
Eisenhower, Dwight 6, 24, 49
 Elison, Marilyn 369
 Elliott, Guy 55
 Elliott, Ronald 171
 Ellis, Linda 246
 Ellison, Adam 399, 410
 Emery, Jeffrey 404, 408-410
 Engelkemeier, Antoinette 51, 84, 279, 355, 359
- Eppley, Richard 133
 Essling, Alice 84, 359
 Estand, Elaine 246, 269, 369, 411
 Evans, Harold 15, 19, 20, 22, 53
 Everhart, Robert 429, 441
- Fagan, James 302
 Fager, Di Ann 150
 Fairgreve, Douglas 84
 Falkenberg, John 191, 411
 Fan, Liang-Shih 276
 Farahat, Magdy 171, 199, 260, 279, 329
 Feay, Bruce 171
 Feder, Harold 17, 19, 22, 30, 35, 43, 48, 54, 55, 66, 67, 82, 95, 108, 111, 121, 130, 147, 199, 232, 244, 334, 369, 450
 Fee, Darrell 191, 224, 225, 274, 276, 279, 329
 Feng, Xiangdong 408, 410, 465
Fenske, Merrill 54
Fermi, Enrico 1, 3, 7, 8
Fermi, Laura 9
Ferraro, Geraldine 238, 241
 Ferry, Florence 84, 136, 141, 142, 149
 Filewicz, Erwin 199
 Finch, Robert 404, 408, 409, 410
 Fineman, Olga (Giacchetti) 15, 22, 158
 Fineman, Philip 15, 19, 22, 46, 63, 78, 103, 158
 Fink, Joanne 199, 220, 301, 320, 329, 446, 450
 Finn, Patricia 178, 216, 289, 291, 292, 404, 409, 444, 447
 Fischer, Albert 112, 133, 171, 191, 199, 260, 291, 292, 444, 457
 Fischer, Donald 81, 124, 159, 199, 219, 312, 319, 401, 429
 Fischer, Jack 65, 70, 71, 96, 112, 127, 159, 220, 229, 279
Fleischmann, Martin 294
 Fletcher, Gregory 429
 Flikkema, Stanley 84, 86
Florin, Al 70
 Flotow, Howard 343, 359
 Folke, Eva 268
Ford, Gerald 139, 140, 144
 Fortner, Jeffrey 404, 410, 411
 Foster, Frank 173
 Foster, Melvin 100, 112, 133, 155, 229

- Fox, Irene 84, 149, 359
 Fradin, Frank 361, 365, 366
 Fraioli, Anthony 274, 286
 Franchini, Anita (see Alamillo)
 Franchini, Guadalupe 246, 369
 Frank, Robert 151, 155, 173, 260, 269, 306
 Fredrickson, Donald 43, 55, 83, 130, 191, 219, 260, 268, 306, 412
 Freeman, Artie 154
Freeman, David 51, 179
Freund, Erwin 8
 Frigo, Arthur 368
Frisch, Otto 1
 Frost, William 171
 Frurip, David 338
Fuchs, Klaus 24
 Fuchs, Louis 230, 355

 Gabelnick, Stephen 156, 220, 248, 368
 Gabor, John 95, 120, 121, 312
 Gabrovic, Dorothea 246
 Gaines, Valerie 245, 246
Gandhi, Indira 239
 Gardner, Marian (see Harkins)
 Garsky, Carol 84
 Gatrousis, Christopher 128
 Gaumer, Lee 15, 20, 22, 70
 Gay, Eddie 153, 161, 171, 254, 260, 268, 306, 310, 312, 422, 429
 Gehrke, Carol 150
 Geller, Jay 172, 173
 Genge, Michael 173, 268
Gentry, Kenneth 161
 Gerald, Rex 376
 Gerding, Thomas 114, 206, 319, 408, 409
 Giacchetti, Olga (see Fineman)
 Gilbreath, James 22
 Gillie, Kenneth 260, 381
 Glassner, Alvin 35, 55, 87
Gofman, John 92
 Goldberg, Margaret 404, 411
Goldwater, Barry 90
 Goodspeed, Harvey 359
Gorbachev, Mikhail 237, 239
 Gore, Albert 361, 362
 Goring, Geoffrey 70, 71

 Gorski, Anthony 286
 Gorth, G. 127
 Goss, Michael 411
 Gourishankar, Karthick 441
 Graae, Johan 36, 40, 63, 64, 105, 155, 160, 171
 Graczyk, Alice 29, 40, 149, 151
 Graczyk, Donald 209, 294, 302, 355, 359, 468
Gray, Hanna 241
 Green, David 149, 153, 159, 220, 245, 246, 329, 357, 359, 367, 468
 Green, Raymond 191
 Greenberg, Elliott 83, 130
 Greenberg, Sherman 15, 22, 199
Greenglass, David 24
 Greenwood, Lawrence 216, 291, 292, 294, 444
Grimmett, E. 76
 Grisko, Sherry 150, 246, 260, 269, 369
 Grosvenor, David 127, 204, 205
Groves, Leslie 3-5, 8
 Gruen, Dieter 287, 352, 457
 Gunderson, Gordon 122, 123
 Gunther, William 114, 124, 329
 Guzman, Gualalupe 246

 Haas, Milton 135, 191, 394
 Hafenrichter, Lohman 404, 409
 Haglund, Robert 192, 199
Hahn, Otto 1
 Halerz, Patricia 368, 369
 Haley, James 127, 220
 Hall, Cynthia 20, 22
Halley, John Woods 345, 464
Hamilton, Robert 161
 Hampson, Donald 20, 22, 43, 51, 55, 63, 76, 103
 Hamrin, David 245
 Hanna, Len 158
 Hanna, Ruth (Peterson) 84, 136, 149, 158
 Harast, Joseph 78
 Hariharan, Alleppey 114
 Harkins, Marian (Gardner) 246, 260, 369
 Harmon, Geraldine 22
 Harmon, Joseph 37, 245, 368
 Harrison, Lawrence 124
Harvey, Paul 34, 359
 Hash, Mark 268, 352, 373, 388, 404, 411, 457
 Hataburda, Paula 150

- Hathaway, Ellen 37, 112, 133, 134, 171, 226-228
 Hausman, Eugene 15, 22
 Hayes, Edward 171, 260, 268
 Hebditch, David 199
 Heiberger, John 199, 205, 229, 274, 312, 334, 423, 429
 Heinrich, Robert 112, 128, 133, 136, 149, 216, 279, 312, 359
 Hejny, Mary Ann 369
 Helt, James 279, 284, 394, 395, 403, 410, 411
 Hendricks, Carol (Richie) 150
 Henriksen, Gary 373, 376, 388, 399
 Henry, Richard 279, 284
 Hepperly, John 191
 Herceg, Joseph 312
Heredy, Laszlo 163, 172
 Hess, David 51
 Hesson, James 61, 63, 124, 133
Hickenlooper, Bourke 7
 Hilberry, Norman 49, 93
Hildebrand, Joel 49
 Hildebrandt, Robert 20, 22, 70
 Hill, Helen 246, 369
Hill, Orbille 21
Hinckley, John 238
 Hirsch, Gideon 110
Hiss, Alger 24
Hitler, Adolph 5
 Hjelte, Beatrice (see Cushing)
 Hlavnicka, Marilyn 84
 Hoekstra, Jodie 15, 22, 84
Hoff, Marcian 155
Hoffer, Eric 110
 Hogrefe, Roger 260, 268, 381
 Hoh, Joseph 302, 404, 408-411
 Holifield, Timothy 260
Holl, Jack 365
 Holloway, Joy (see Swoboda)
 Holmes, John 121, 127, 147, 193, 195, 199
 Holt, Ben 149, 232, 355, 357, 467
 Homa, Myron 20, 22, 51, 83, 84, 136, 149, 171, 291
 Hon, L. 461
 Hon, Ping-Kay 125
 Honesty, Charles 125, 199
 Hoover, Alberta 43, 83
 Hornstra, Fred 170, 171, 173, 260, 268
 Horwitz, Philip 302
 Hsu, Chen-Chao 191, 268
 Huang, Hann-Sheng 191, 274, 279
 Hubbard, Ward 38, 82, 95, 130, 147, 159, 217, 343
 Hubble, William 191, 355
Hudson, Ray 161
 Huff, Doris 359
 Huff, Edmund 306, 312, 359
Huggins, Robert 162
 Hulet, Donald 76
Humphrey, Hubert 90
 Humphrey, Jimmy 199
 Hunt, Paul 171
 Hunt, Peter 110, 111, 123
Hussein, Sadam 362
 Hutter, Joseph 418
 Hykan, Edwin 20, 22, 76
 Hyman, Herbert 7, 15, 17, 21, 22, 65, 70

Iizuka, Masatoshi 429
 Isaacson, H. Ronald 355
 Ivins, Richard 82, 95, 124, 161, 172

 Jacobson, David 15, 22
 Jacobson, Joseph 22
 Jaffey, Arthur 51
 Jansen, Andrew 373, 375-377
Janz, George 162
 Jardine, Leslie 199, 206, 319
 Jarry, Roger 65, 114, 135, 191
 Jaskot, Raymond 306, 412
 Javdani, Kambiz 191
 Jensen, Kenneth 149, 312, 359
 Jensen, Lucille 246
 Jivery, Barbara 150
Jobs, Steven 155
 Johnson, Andrew 377
 Johnson, Carl 86, 114, 125, 133, 147, 171, 191, 210, 225-227, 245, 246, 282, 289, 292, 329, 444
 Johnson, Carter 97
 Johnson, Christine 369
 Johnson, Christopher 376
 Johnson, Gerald 83, 130, 312, 313, 338, 441, 458
 Johnson, Irving 38, 55, 95, 100, 107-111, 156, 180, 191, 229, 276, 279, 312, 313, 329, 429
Johnson, Lyndon 90

- Johnson, Stanley 112, 133, 171, 226, 232, 282, 352, 355, 457, 465
 Johnson, Terry 30, 61, 108, 127, 191, 204, 279, 282, 312, 401, 404, 410, 411, 416, 426, 429
 Johnston, Ernest 61, 151
Joliot-Curie, Frederick 1
 Jones, Loretta 111
 Jones, M. 119
 Jonke, Albert 15, 22, 53, 72, 74, 76, 93, 112, 120, 135, 147, 180, 243, 244, 246, 279
 Juco, Eleanor (see Kafalas)
 Jurlow, Miriam 84
 Juvinall, Ruth 78, 84, 136, 149, 206
- Kacinskas, Henry 171
 Kafalas, Eleanor (Juco) 158
 Kafalas, Peter 86, 158
 Kahaian, Arthur 376
 Kaminski, Michael 411
Kanasugi, Katsumasa 429
 Kann, William 312
 Kaplan, Bettye 22
 Kaplan, Louis 22
 Karell, Eric 441
 Kartunnen, John 149
 Kassner, Thomas 191, 199
 Katz, Joseph 21, 65, 70
 Kaun, Thomas 167, 171, 256, 260, 268, 274, 372, 373
 Kazadi, Msiri 248
 Keday, Alec 22
 Keener, Richard 245
 Keigher, Mary 150
Keil, Klaus 230
 Keledus, Tony 155
 Keller, Rudolf 206
 Kelley, John 260
 Kelsheimer, Pleasant 151, 154
Kemp, Jack 361
 Kennedy, Carolyn 15, 22
Kennedy, John 89, 90
Kennedy, Robert F. 90
 Kepler, Keith 376
 Kesser, Gwendolyn 37, 84, 85, 149, 245
 Kessie, Robert 70, 71, 74, 114, 118, 156, 171, 199, 206, 248, 312
- Khanna, V. 111
Khrushchev, Nikita 25, 89
 Kilbourne, Byron 31
 Kilian, Kerri 246, 269
Kilpatrick, Martin 82
 Kilsdonk, Dennis 171, 260
 Kincinas, John 120, 171, 302
 King, James 15, 22
 King, Judith 150
King, Martin Luther 90
 Kinoshita, Kim 178, 274
 Kirby, Jack 99
 Kleb, Robert 130, 348
 Klein, Milton 15, 22
 Klemmer, Robert 291
 Klinger, Jiri 173, 268, 282, 286
 Klingler, Robert 334, 376, 455
 Kloska, Corinne (see Thompson)
 Kmiec, Richard 268
 Knapp, William 125
 Knighton, James 55, 84, 108-110
 Knudsen, Irving 119, 123
 Kobayashi, Masaru 121
Kobayashi, T. 429
 Kolba, Verne 171, 193, 195, 199, 260, 274, 301
 Kopasz, John 399, 444
Koppel, Lowell 121, 191
 Kosner, Carol 136
 Kitora, James 154
 Koura, Nobuyuki ("Nick") 171
Koyama, Tadafumi 429
 Kraft, Theodore 274
 Krause, Douglas 20, 22, 31, 78, 83, 84
 Krause, Paul 127
 Krause, Theodore 334, 388, 395, 399, 410, 411
 Kremesec, Victor 301
 Kreamsner, Walter 111, 171, 199, 229, 230, 260, 286, 355
 Kronenberg, Marvin 268
 Krumpelt, Michael 205, 229, 274, 294, 346, 388
 Kucera, Eugene 84, 112, 128, 133, 136, 149, 158
 Kucera, Gene (McCloud) 84, 158, 171, 178, 227, 229, 230, 260, 274, 388
 Kueper, Timothy 388
 Kulaga, Joseph 248, 368
 Kullen, Bruce 78, 206

- Kumar, Romesh 199, 206, 232, 284, 355, 388
Kummer, Joseph 260
Kurchatov, Igor 24
 Kwok, Jane 306, 418
 Kyger, Jack 146
 Kyle, Martin 30, 108, 153, 165, 171
- Laidler, James 361, 366-368, 404, 429
 Lamb, Wendy (Donnelly) 246, 269
 Lamoureux, Laura (Chromizky) 359
 Land, Robert 156, 216, 248, 292
 Landis, Dawn 246, 269
 Lane, Linda 369
 Laney, Robert 40, 42, 146
 Lang, Teresa 246, 355
Langmuir, Irving 6
Lapp, Ralph 25
 Larsen, Karen 367
 Larsen, Robert 30, 35, 37, 43, 53, 76, 84-86, 136, 147-149, 160
 Latimer, Trent 171
 Lavendel, Henry 61
Lawrence, Ernest 2, 8, 10
Lawroski, Harry 50
 Lawroski, Stephen 13, 15-19, 22, 30, 31, 39, 40, 43, 47-50, 71, 72, 74, 76, 79, 87, 89, 92, 96, 149, 234, 364
 Leddin, Jacqueline (see Copple)
 Lee, Henry 22
 Lee, Johnsee 268
 Lee, Sheldon 191, 279, 388, 392, 404
 Lee, Tien 173, 268
 Legerski, Lee 246
 LeGrand, Charlotte 246, 269
 Lehmann, Clarence 127
 Lehmann, Jacqueline 150
 Leibowitz, Leonard 81, 95, 124, 199, 219, 220, 292, 301, 312, 320, 329, 429, 446, 450
 Lemke, Vernon 136, 149
 Lenc, John 127, 191, 205, 276, 279
 Leonard, Ralph 198, 199, 205, 289, 291, 302, 306, 412, 415, 416, 418
 Leonard, Sally 150
 Lescarret, Alain 191
 Levenson, Milton 17, 19-22, 45, 51, 58, 59, 61, 63, 70, 95, 98, 102, 105, 137, 369
- Levison, O. 76
 Levitz, Norman 20, 22, 51, 74, 119, 147, 202, 204, 206, 207, 209, 302
 Lewandowski, Edward 155
 Lewin, Janice (see Muller)
 Lewis, Michele 269, 302, 312, 401, 426, 429
 Lexa, Dusan 429
 Liimatainen, Robert 70, 71, 74, 82, 124
Lilienthal, David 7
Lincoln, Abraham 65
 Lindahl, Peter 279, 359, 409, 467, 468
 Link, Leonard 234
 Linzer, Frederick 43
 Litland, Howard 15
 Littmen, Henry 22
Litty, Albin 74
 Liu, Yung 329
 Loeding, John 20, 22, 36, 51, 53, 72, 76, 79, 120, 159, 234
 Long, Ray 35, 70
 Loutfy, Ralph 206, 268, 346
 Ludewig, Walt 70
 Ludlow, John 105
 Luner, Charles 111, 193, 199
 Luo, Jian Shu 404, 410, 457
- MacArthur, Douglas* 23
 Mack, Paul 108, 193, 195, 199
 Madson, Allen 128
 Madson, Sheila 150
 Malak, Laurie (see Carbaugh)
 Malak, Stephanie (Malm) 246, 369
Malcolm X 90
 Malecha, Richard 36, 40, 63, 101, 155, 161, 172, 260, 291, 312, 368, 429
 Malewicki, Russell 136, 149
 Malm, John 70
 Malm, Stephanie (see Malak)
 Mandelstein, Les 22
 Manevy, George 114
 Manimelto, Michael 376
 Marchetti, Frank 35
 Marek, Lawrence 20, 22, 193, 199
 Margolis, Asher 22
 Markun, Francis 359, 467

- Maroni, Victor 95, 112, 134, 159, 171, 210, 216,
 226-228, 287, 292, 329, 348, 350, 352, 444, 450,
 457, 459, 461, 465
 Marr, Jane 171, 227, 229, 260, 268, 338, 359
 Marshall, Christopher 459
Marshall, George 6, 24
 Marshall, Samson 307, 418
 Martin, Allan 55, 110, 122, 123, 147, 171, 227
 Martin, Peter 82
 Martino, Fredric 136, 149, 171, 260, 302, 359, 468
 Maser, James 319
 Mason, Donald 82
 Mason, George 10, 22
 Massey, Walter 139, 145, 237, 241
 Masten, Frank 97, 151
 Mathers, James 171
 Matlak, Sharon 150
 Mau, Cindy (see Meurer)
 Mazer, James 408, 410
McAuliffe, Christa 239
 McBeth, Robert 159
 McBride, Peggy (see Parks)
 McCann, Debra 150
McCarthy, Joseph 24
 McCloud, Gene (see Kucera)
 McCown, John 83, 84, 103
 McDeavitt, Sean 429
 McGarity, Arthur 286
McGovern, George 139, 140
 McIntire, William 202
 McKee, John 159, 193, 195, 199
 McKinney, Susan 369, 411
 McLaughlin, Malika 369
McMahon, John 344
 McPheeters, Charles 159, 171, 195-199, 274, 297,
 301, 367, 429, 441
 Mead, Lee 151
 Mecham, William 21, 22, 30, 70, 71, 74, 95, 137,
 199, 206, 318, 319
 Meisenhelder, Janet 205, 268
Meitner, Lise 1
 Melendres, Carlos 171, 346, 352, 450, 465
 Melton, Anne 149, 151, 246
 Mendez, Vanessa (Arzate) 368, 369
 Mensah-Biney, Robert 399
 Mertz, Carol 399, 410
 Metz, Clyde 131, 399, 410
 Meurer, Cindy (Pospishil, Mau) 246
 Meyer, Robert 85, 125, 136, 147, 149, 192, 199,
 248, 302
 Michalek, Doris (see Worthington)
 Miller, James 173, 260, 388
 Miller, John 269
 Miller, Shelby 99, 279, 392
 Miller, William 105, 147, 159, 161, 171, 199, 204,
 260, 307, 308, 312, 420, 423, 429
 Mingh, Nguyen 269
 Mishler, Larry 81, 124
 Misra, Balabhadra 199, 216, 260, 282, 289, 291,
 292, 294, 301, 312, 429
 Mojica, Lilia (see Barbosa)
 Moncton, David 365
Mondale, Walter 238
 Montagna, John 191
 Moore, Mary 150
 Morgan, Deborah (see O'Rourke) 246
 Morrissey, Leo 152, 159, 368
 Morss, Lester 404, 411
 Moulton, David 191
 Mowry, Russell 191, 279
 Mrazek, Franklin 122, 123, 131, 171, 260, 269, 274,
 306, 373, 388
Muehlenbachs, K. 356
 Mueller, Catherine 150
 Mulcahey, Thomas 191, 269, 312, 313, 429, 441
 Muller, Janice (Lewin) 42, 154, 246, 368, 369
 Mundy, John 171
 Munnecke, Victor 19, 22, 47-49, 53, 92, 97
 Murphy, William 159, 191
 Murray, Richard 111, 149
 Murrell, M.T. 465
 Myers, Deborah (Zurawski) 388
 Myers, Henry 429
 Myles, Kevin Michael ("Mike") 163, 166, 171, 180,
 227, 229, 260, 268, 269, 274, 276, 279, 282, 284,
 294, 367, 388, 450
 Nagy, Zoltan 338, 346, 450, 459, 465
 Nandi, Satyendra 191
 Napora, Sofia (Gawenda) 150, 153, 246, 368, 369
 Natale, John 15, 19, 20, 22, 51, 101, 151
 Nathans, Marcel 55

- Neir, Alfred* 3
Nelson, L. S. 230
Nelson, Paul 30, 61, 93, 96, 127, 146, 147, 153,
 159, 161, 172, 192, 193, 195, 199, 243, 244, 246,
 259, 268, 367, 373, 404
Nelson, Robert 206, 279, 302
Nevitt, Michael 146
Newman, Aron 429
Newman, John 162
Newnam, Steven 359
Newsam, John 348
Nicholson, E. 68
Nielson, Eugene 355, 376
Nishimura, Tomohiro 429
Nishio, Kazuo 108, 124
Nixon, Richard 89, 90, 139, 140, 179
Nolan, Bonnie 150
Nole, Michael 404, 411
Noriega, Manuel 239, 362
North, Oliver 238
Novey, Theodore 51
Nuñez, Franklin 279
Nuñez, Luis 191, 410, 412
Nuttall, Ralph 55, 56, 83, 130

O'Conner, Sandra Day 241
O'Hare, Patrick 95, 130, 217
O'Leary, Hazel 25
O'Neil, Florence 40
O'Rourke, Deborah (Morgan) 246
Ogata, Takanari 429
Okajima, Shigeo 403, 409
Oldham, Robert 136, 149
Olsen, William 39
Olszanski, Ruth (Voiland) 158
Olszanski, Theodore 158, 171
Oppenheimer, Robert 4, 7, 8
Osborn, Marilyn 246, 369
Osudar, John 156, 171, 248, 368
Oswald, Lee Harvey 90
Otto, Neil 171, 260

Pacholok, Maria 369
Panek, Allen 136, 149, 192, 199
Panek, Marge (Swanson) 150
Papatheodorou, George 346, 465

Parks, John 206, 286, 302
Parks, Peggy (McBride) 246
Paul, Nola Joy (Tasharski) 158
Paul, Ron 158, 269
Pauling, Linus 110
Pavlik, John 61, 124, 127, 191, 199
Payne, Charles 127
Peck, James 112, 124, 133, 134
Pehl, Wilfred 61, 76
Peierls, Rudolph 1
Pelto, Ralph 216, 306
Pelton, Arthur 279, 329, 338, 351
Pereira, Candido 429
Perot, Ross 362
Peterman, Ray 216
Peterson, Edwin 19, 22, 40, 158
Peterson, Elizabeth (Reilly) 20, 22, 31, 84, 158
Peterson, Laureen (Seils) 22, 158
Peterson, Ruth (see Hanna)
Petkus, Edward 72, 74, 79, 127
Petrick, Michael 191
Pewitt, Gale 146
Pfann, William 57
Pfeiffer, Carl 159
Pierce, Kenneth 465
Pierce, R. Dean 38, 61, 99, 100, 108, 127, 147, 159,
 178, 204, 205, 274, 313, 441
Pike, Sumner 7
Pinches, Norma (see Brown)
Pizzolato, Philip 81
Planner, H. N. 230
Poa, David 173, 269, 312, 313, 441
Podolski, Walter 191, 279, 388, 392
Poeppel, Roger 274
Pollack, Israel 155, 172
Pollard, Richard 162
Pons, Stanley 294
Popek, Ray 83, 84, 136, 149, 294
Popik, Judith 246, 274, 368, 369
Pople, John 342, 346, 458
Porte, Howard 114, 130
Pospishil, Cindy (see Meurer)
Post, Roy 22, 250
Powell, Mary 369
Powers, Gary 89, 369
Prakash, Jai 375, 376

- Preto, Sandra 159, 170, 171, 260
 Preuss, Daniel 368
 Price, David 458
Price, Melvin 25
 Proud, Everett 93, 97, 99, 110, 146, 147, 149, 151, 154, 246
 Prucha, Doreen 100, 149, 151, 154
 Prucha, Lad 100
 Pyle, Julitta 150

 Quattropani, Nick 127, 204, 205, 312, 422, 429
Quayle, Dan 238, 361, 362
 Quigley, Kevin 404, 411
 Quinn, John 404

Rabi, Isador 7
 Rafacz, Evelyn 40, 149
 Rajan, John 173, 269, 274, 284, 306, 368
 Ramaswami, Devabhaktuni 121, 127, 191
 Raphaelian, Leo 279
 Raptis, Penelope 245
 Rashinskas, Anthony 108
 Rathke, Jerome 232, 334, 450, 455, 459
 Raue, Donald 119, 193, 195, 197-199, 301, 302, 312
 Rauh, Everett 359
 Rausch, Debra 369
Ray, James Earl 90, 108, 136, 301
Reagan, Ronald 237-239, 249, 365
 Redding, George 67, 111, 114, 171, 229, 260
 Redey, Laszlo 164, 171, 251, 260, 269, 294, 307, 346, 373, 375, 376, 377
 Reed, Donald 401, 403, 409, 411
 Reed, Kent 202
 Reedy, Gerald 220, 291, 319, 359, 465
 Regalbutto, Monica 306, 412, 416
 Reichley-Yinger, Lucinda 306
 Reilly, Elizabeth (see Peterson)
 Reishus, John 121, 122
 Reiter, Sandra (see Tummillo)
 Renner, Thomas 197, 198, 199
Reuther, Walter 25
 Rhode, Kenneth 43, 55
 Richards, Darcell 150
 Richardson, H. L. 230
 Richie, Carol (see Hendricks)

 Richmann, Michael 403, 429
Rickover, Hyman 7, 25, 28, 97, 140
Ride, Sally 241
 Riel, Roberta 246, 368, 369, 411
 Riha, James 114, 171, 191
 Ritzman, Robert 329
 Rizzi, Lysbeth 369
 Roberts, John 243, 244
 Robinson, Mary 84, 141
 Roche, Michael 161, 171, 192, 193, 199, 260, 329, 388, 446
 Rodger, Walton 17, 19, 20, 22, 35, 36, 48, 49, 70, 71, 74, 76, 79, 82, 91, 92
 Rodighiero, Susan 150
 Roessler, Susan (Cathimer) 150
 Rogers, Chester 124, 134
Roosevelt, Franklin 2, 6, 24
 Rosen, Charles 55
Rosenberg, Ethel 24
Rosenberg, Julius 24
 Rosenthal, Seymour 22
 Ross, Laurids 15, 22, 84, 85, 125, 136, 149, 171, 192, 199, 260, 359
 Ross, Norman 101
 Royal, Joseph 37, 96, 147
Rubischko, Richard 161
Ruby, Jack 90
 Rudolph, Heidi 246
 Rudzitis, Edgars 83, 89, 130
 Ruppert, Lewis 269, 302
 Rura, Susan (Bykowski) 246, 260, 369, 411
 Rush, Robert 202
 Ruther, Westly 193, 199
 Ryberg, Carl 78

 Sabau, Carmen 279, 306, 359
 Saboungi, Marie-Louise (Blander) 158, 171, 227-229, 338, 459
 Sachs, Robert 139, 145
Sadat, Anwar 140
 Sandus, Oscar 74
Sano, Y. 356
 Santelli, Dino 136, 149
 Sato, George 84
 Savage, James 114, 120
Saxena, Satish 191, 279

- Scandora, Anthony 291
 Scaropoulos, Maria (see Contos)
 Schablaske, Robert 20, 22, 51, 83, 84, 110, 133, 136, 149, 171, 227
 Schertz, William 156, 171, 202, 284, 286
 Schierbeek, Gina 369
 Schilb, Arden 78, 84
 Schilb, John 76, 84, 108, 127
Schlessinger, James 145
 Schlueter, Richard 193
 Schneider, Alfred 61, 78
 Schneider, John 279, 284, 359, 411
 Schnizlein, Glenn 65, 70, 81, 206
 Schnyders, Harold 229
 Schoeneman, Karl 22, 43
 Schoffstall, Charles 120, 121, 191, 279, 282
 Schoij, Norman 155
 Schraidt, John 15, 19, 20, 22, 33, 36, 39, 40, 51, 61, 63, 101, 102, 105, 151, 152, 154
 Schriesheim, Alan 237, 241, 361, 365, 366
Schriesheim, Beatrice 247
 Schulze, William 36
Seaborg, Glenn 3, 6-8, 11-13, 21, 110
Secord, Richard 238
 Sedlet, Jacob 306, 412, 418
 Seefeldt, Waldemar 22, 51, 70, 71, 74, 137, 206, 234, 306, 318, 411
 Seils, Charles 20, 22, 43, 51, 84, 125, 136, 149, 158, 294, 329, 411
 Seitz, Martin 206, 317, 319, 357
 Selman, J. Robert ("Rob") 162, 171, 176
 Settle, Jack 83, 130, 158, 163, 171, 312, 329, 338, 346, 420, 429, 446
 Settle, Leila (Buckner) 158
 Seufzer, Paul 70
 Shablaske, Robert 112, 114
 Shaffner, Irving 22
 Sharma, Ram 226, 229
Shaw, Milton 97, 98, 145
 Shearer, John 191, 276, 279, 292
 Sheft, Irving 65, 70
Shepard, Alan 90
 Sheth, Atul 191, 199, 282
 Shields, Kathleen 246, 369
 Shiffer, Vita 150
 Shimotake, Hiroshi ("Paul") 133, 134, 161, 171, 260, 269
 Shinn, William 70, 114, 122, 329
Shockley, William 37
 Shor, Arthur 15, 22, 158
 Shor, Roberta (Wagner) 22, 43, 53, 86, 114, 158
 Shull, Daniel 411
 Siczek, Aldona 205
 Siegel, Stanley 136, 149, 171, 191, 355, 359
 Siegfried, Yolantha 368
Silkwood, Karen 145
 Silverman, Martin 124
 Sim, James 171, 178, 274
 Simmons, John 37, 245
 Simon, Daniel 377
 Simpson, Lin 404
 Singleterry, Merrill 269
 Singleton, Ernest 155
Sirhan, Sirhan 90
 Skladzien, Stanley 192, 193, 195, 198, 199, 301
 Slater, Susan 409, 429
 Slawecki, Michael 105, 195, 199, 291, 312, 368, 429
 Smaga, John 165, 171, 257, 260, 269, 381
Smiley, Seymour 74
 Smith, Charles 301
 Smith, Dale 192, 410
 Smith, Florence (Williams) 136, 149, 312, 359
 Smith, Gregory 136, 191, 269, 276, 279
 Smith, Harry 36, 40, 101, 155
 Smith, James 274, 388, 429, 441
Smith, Joseph 339
 Smith, Sherman 191, 279
 Smith, Walter 35
 Smither, Robert 294
 Smyk, Eugene 191, 282
Smyth, H. 6
 Snyder, Christine 359, 394
 Snyder, Robert 191
 Sobczak, Maureen 149
 Sockman, Charles 57
 Sovereign, William 36, 43, 83, 84, 103
Spedding, Frank 7
 Spencer, Bruce 329
 Spicer, William 51

- Sridhar, Ramamritham 134, 171, 226
 Srinivasan, Balasubrahmanyam ("Chino") 418
 St. Germain, Renee 150
 Staahl, Gustav 125
 Stagg, Amos Alonzo 2
 Stakem, Douglas 161
 Stakkowski, Jackie 150
 Stalica, Norbert 125, 136, 149
 Stalin, Joseph 6, 25
 Stapay, Joseph 274, 388
 Starr, Kenneth 361, 362
 Stavropoulos, George 193, 199
 Steidl, David 43, 70, 71, 78, 114, 329, 446
 Stein, Lawrence 65, 68-70, 83, 129
 Steindler, Martin 30, 31, 43, 67, 71, 78, 86, 100,
 112, 114, 147, 160, 205, 206, 237, 243, 244, 246,
 247, 301, 318, 361, 366, 367
 Steinquist, Janet 150, 246, 359
 Sternglass, Ernest 92
 Stethers, Howard 105
 Steunenberg, Robert 49, 65, 66, 67, 70, 71, 74, 93,
 96, 106, 110, 147, 161, 164, 171, 260, 274, 312
 Stevens, Charles 76, 359
 Stevens, J. 76
 Stevenson, Adlai 24
 Stevenson, Charles 18, 19, 22, 30, 39, 40, 49, 62,
 76, 88, 102, 147, 209
 Stimak, Raymond 155
 Stimson, Henry 6
 Stockbar, John 114, 191, 279
 Stockman, Charles 240
 Stockman, David 240
 Stogsdill, Carol 246, 369
 Story, Vincent 6, 20
 Strachan, Denis 404, 408, 410
 Strachan, Marietta 369
 Stratton, Janet (see Carothers)
 Strassman, Fritz 1
 Strauss, Lewis 7
 Streets, Elane 359
 Stretch, Carl 124
 Strezo, Virginia 246, 359, 369, 411
 Strle, Wendy (see Zanelli)
 Stupegia, Donald 128
 Sturchio, Neil 317, 319, 357, 467
 Sudar, Seymour 161
 Sullivan, Kathryn 241
 Surchik, Mark 409
 Susman, Sherman 342
 Swanson, Marge (see Panek)
 Swanson, Stephen 359
 Swaroop, Robert 171, 260, 279
 Sweezer, Robert 84
 Swift, David 124
 Swift, William 180, 191, 279, 282, 388, 392, 394
 Swoboda, Carl 158, 269
 Swoboda, Joy (Holloway) 149, 158
 Swope, Gladys 22, 77-79
 Sy, Condeocita (Cajigas) 161, 171, 291
 Sze, Dai-Kai 394, 444, 447
 Szilard, Leo 1, 2, 3
 Taecker, Rollin 49, 72
 Tam, Shiu-Wing 291, 292, 329, 352, 404, 408, 444,
 457, 459
 Tamplin, Arthur 92
 Tamura, Takeo 119
 Tani, Benjamin 95, 110, 136, 149, 171, 352, 355,
 359, 409, 410, 457, 465
 Tasharski, Nola Joy (see Paul)
 Tasker, Ian 306, 343, 411, 412
 Taube, Henry 48
 Taylor, Audrey 246
 Teats, Gale 108, 191, 204, 279, 368, 392
 Teitlus, Martha 368, 369
 Telford, Ralph 149
 Teller, Edward 2, 8
 TenKate, Lynn 359
 TenKate, Tony 359
 Terdic, Heidi 368, 369
 Terkel, Studs 110
 Terry, Rosemary 108, 127, 130
 Testa, Frank 82, 124
 Tetenbaum, Marvin 19, 81, 95, 122, 123, 131, 199,
 292, 301, 329, 338, 352
 Tevebaugh, Arthur 70, 93, 95, 97, 112, 124, 133,
 145, 146, 161
 Thackeray, Michael 376, 377
 Thigpen, Johnathan 70
 Thompson, Augustella 37
 Thompson, Corinne (Kloska) 20, 22
 Thorn, Robert 122

- Tiedemann, William* 162
Till, Charles 243, 307, 365, 367
Tipton, Donna 246, 369
Tobias, Charles 95, 162
Tobias, Kenneth 108, 110
Todd, Mary 65
Tokiwai, M. 429
Tollner, Ronald 42, 368
Tomczuk, Zygmunt 136, 149, 159, 164, 171, 260, 308, 312, 420, 423, 429
Tomlinson, Glen 302
Tosi, M. 458
Towle, Warren 162
Trevorrow, LaVerne 70, 74, 114, 171, 206, 302, 306, 412, 429
Trice, Virgil 20, 22, 51, 53, 95, 137
Trischan, John 127
Truman, Harry 6, 24, 25
Tsai, Yifen 359
Tse, Pui-Kwan 306
Tsuchie, Yasuo 429
Tummillo, Anthony 260, 269, 381, 388
Tummillo, Sandra (Reiter) 246, 369
Tuohig, Wayne 171
Turk, Elton 19, 22, 53, 78
Turner, Clarence 191
Turner, Robert 376
Tyler, Homer 20, 22, 70

Uhle, Ronald 55
Urey, Harold 2, 21

Van Dahm, June 246
Van Deventer, Erven 110, 130, 292, 306, 399, 412, 444
Vandegrift, George 279, 302, 306, 307, 317, 319, 394, 404, 411, 412, 416, 418
Vargo, Noel 171, 191, 205
Varma, Ravi 260, 269, 279, 284, 395
Varteressian, Kegham 20, 22, 54, 124
Vasilopoulos, George 269
Vaughey, John 376, 377
Veleckis, Ewald 110, 111, 159, 199, 216, 227, 229, 292, 319, 329, 338, 409, 450
Vest, Michael 441
Vilinskas, Peter 199

Visser, Donald 111, 161, 164, 170, 171, 193, 195, 196, 199, 251, 260, 269, 279, 284, 294, 306, 307, 319, 373, 418
Vogel, John 74, 97, 117, 180, 247, 279
Vogel, Richard 19, 20, 22, 38, 49, 51, 55, 70, 71, 81, 86, 89, 92, 96, 139, 146, 147, 149, 150, 156
Vogler, Seymour 15, 22, 37, 43, 51, 53, 55, 71, 86, 127, 204, 291, 411
Voiland, Eugene 148
Voiland, Ruth (see Olszanski)
Volin, Kenneth 342
Von Winbush, Sam 176
Voss, Denise 246
Voss, William 20, 22, 36, 51, 155

Wach, Charles 55, 206, 302
Wade, Warren 70
Wagner, Bruce 162
Wagner, Roberta (see Shor)
Walker, David 171
Walker, Prince 302
Wall, Katherine 150, 237
Walling, Matthew 22
Walsh, William 97, 108, 159, 161, 171
Walters, William 15, 22
Wang, Xiaoping 388
Wantroba, Alvin 202, 286
Warchal, Raymond 82
Warinner, Douglas 282
Warren, David 312, 429, 441
Waters, Jodean 173
Watson, Thomas 3
Waughan, D. E. W. 348
Waymach, William 7
Weber, Carl 269
Weber, John 260, 269, 279
Weber, Neil 260
Webster, Carl 260, 381
Webster, Donald 19, 93, 146, 147, 161, 202, 205, 243, 244, 246
Weeks, Colleen 246
Weiler, Candace 150
Weinberg, Alvin 91
Weinstock, Bernard 70
Welch, Joseph 25
Wenz, Donald 108

- Wesolowski, Cynthia 160, 246, 369
 Wesolowski, Eugene 441
 West, Elmo 2, 3, 10, 11, 13, 18, 20, 22, 191
 Weston, James 216
 Wetter, Lesa 359
 Wheeler, John 1
 White, George 126
 White, Mary Lou 369
 Wigeland, Ronald 306
 Wigner, Eugene 2, 7, 28
 Wilkinson, Cynthia 246
 Williams, Florence (see Smith) 279, 312
 Williams, Jacqueline 20, 22, 51, 84, 128, 149
 Williamson, Kenneth 120
 Williams, Samuel 356
 Willis, Kathy 246
 Willit, James 424, 429
 Wilson, Melania 150
 Wilson, Robert 124
 Wilson, Tim 171
 Wilson, W. Ira 191, 276, 279
 Windsor, Paulette 37
 Wingender, Ronald 158, 284, 359
 Winsch, Irving 22, 61, 108, 127, 204, 206, 302
 Winston, Roland 200
 Wise, Stephen 83, 130
 Wise, William 339
 Wist, Thaddeus 155
 Wolf, Stephen 404, 408, 409, 410, 411
 Wolkoff, Jasper 61
 Wolson, Raymond 42, 108, 198, 199, 301, 308, 368
 Wong, Samuel Hei-Yu 276
 Wood, Patricia (see Canaday)
 Wood, Scott 161
 Woods, Kenneth 35
 Worrell, Wayne 162
 Worthington, Doris (Michalek) 158, 246
 Wozniak, Stephen 155
 Wronkiewicz, David 408, 409, 410
 Wygmans, David 410, 416, 418

 Yaeger, Ernest 162
 Yannopoulos, Lymperios 122
 Yao, Neng-Ping ("Mike") 153, 163, 171-173, 258, 268, 269
 Yasui, George 22, 79

 Yeltsin, Boris 361
 Yokoo, Takeshi 429
 Yonco, Robert 55, 110, 111, 171, 216, 227, 229, 292, 338, 346, 350
 Yoshida, Takuma 429
 Yoshioka, Marion 22
 Young, Hoylande 33
 Young, John 180, 274, 279, 284, 408
 Youngdahl, Arthur 198, 199

 Zanelli, Wendy (Strle) 246, 269, 369
 Zeno, Esmer 43, 86
 Zepeda, Irma 368, 369
 Ziegler, Anton 205, 279, 302, 306
 Zielen Albin 172
 Zinn, Walter 3, 7, 8, 17, 43, 49, 94
 Zivi, Samuel 172
 Zwick, Stanley 274, 282
 Zygmunt, Stanislaus 461

