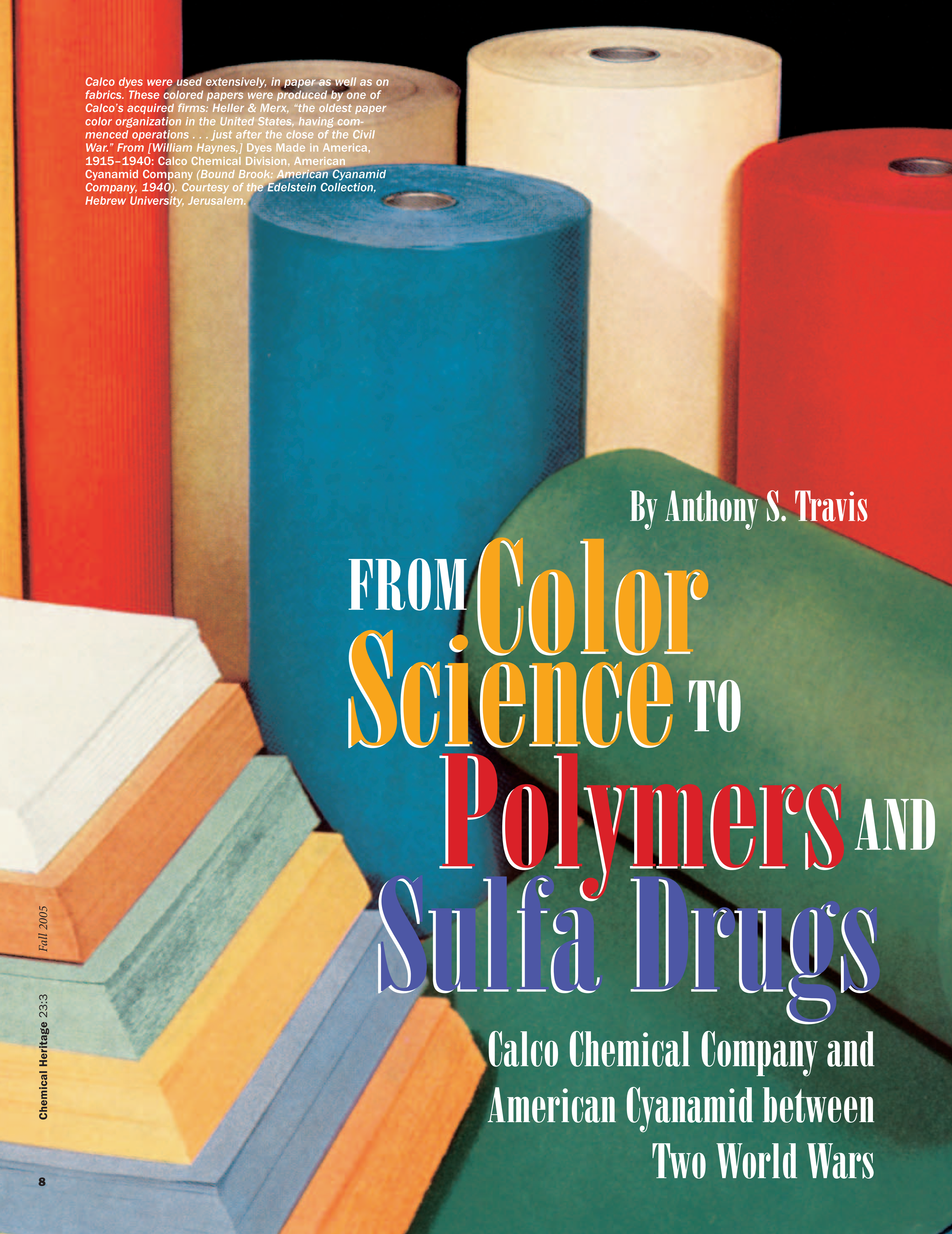


Calco dyes were used extensively, in paper as well as on fabrics. These colored papers were produced by one of Calco's acquired firms: Heller & Merx, "the oldest paper color organization in the United States, having commenced operations . . . just after the close of the Civil War." From [William Haynes,] Dyes Made in America, 1915–1940: Calco Chemical Division, American Cyanamid Company *(Bound Brook: American Cyanamid Company, 1940). Courtesy of the Edelstein Collection, Hebrew University, Jerusalem.*

By Anthony S. Travis

FROM Color Science TO Polymers AND Sulfa Drugs

Calco Chemical Company and American Cyanamid between Two World Wars

One day in January 1943 the singer and actor Paul Robeson arrived at a remote New Jersey factory to give a recital as memorable as any performance he had given on Broadway or in Hollywood. The backdrop, the Bound Brook facility of the Calco Chemical Division of the American Cyanamid Company, comprised chemical reactors, storage tanks, filter presses, and distillation columns. The occasion was the presentation of the prestigious Army-Navy E pennant, for excellence in contributing to the war effort.

Over the previous three years the 3,000 men and women employees of Calco who turned out to hear Robeson had driven themselves to exhaustion coaxing machines to provide seemingly mundane materials that proved strategic boons to Allied forces: amino plastics and melamine resins, including all-weather map laminates, dyestuffs and pigments (as camouflage colors and aids to locate airmen downed at sea, as well as for coloring uniforms), explosives intermediates, rubber and textile additives, and the new sulfa wonder drugs.

Robeson's concert was just one notable event in the history of Calco, originally a small independent company. Its products, developed mainly in the 1930s, helped make American Cyanamid the fourth largest—and certainly the most diversified—chemical corporation in the United States.

Robert C. Jeffcott (1876–1961) was the moving force behind the creation of Calco Chemical Company "for the purpose of manufacturing chemicals, some dye stuffs, and other allied products," as he wrote in a report to the stockholders of Calco's parent company, Cott-A-Lap. The Chemists' Club Collection, CHF Collections.

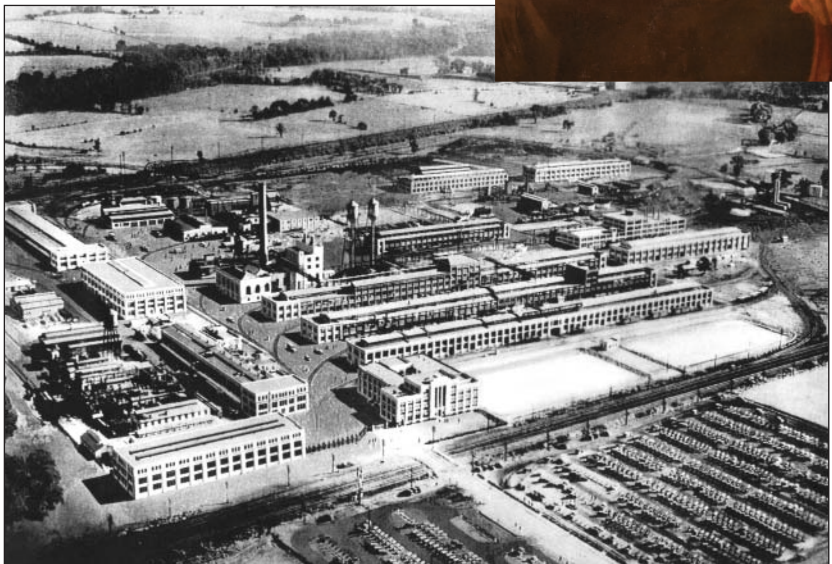
Origins: Dyes Made in America

The United States took its first faltering step into the modern organic chemicals industry through large-scale dyestuff manufacture, in direct response to the outbreak of war in Europe in 1914. When hopes that the war would end quickly were abandoned by the spring of 1915, American manufacturers found themselves facing long-term shortages of many imported products, particularly German-made coal-tar dyestuffs. Until then the power of the German dye industry—especially its control of patents and its strong marketing organizations—had suppressed the development of the coal-tar chemical industry in the United States. The British blockade on German shipping, combined with Germany's abundant supply of dye intermediates for military purposes, compelled the American chemical industry and textile manufacturers to pursue an energetic—and successful—strategy aimed at self-sufficiency in coal-tar chemical manufacture.

One of the first efforts was the creation of the Calco Chemical Company, the offspring of a textile manufacturer, the Cott-A-Lap Company, of Somerville, New Jersey, which specialized in burlap wall coverings. Under Robert C. Jeffcott (1876–1961), Cott-A-Lap began investigating aromatic intermediates for dyes, using information gleaned from German textbooks, bench research, and advice from a Yale University professor—Treat B. Johnson, a former classmate of Jeffcott's. Pressure from the firm's neighbors, worried about pollution, led Jeffcott to set up Calco as a separate firm on the Raritan River near Bound Brook, New Jersey.

There, after a great deal of trial and error, Calco built up expertise in intermediates manufacture. In 1917 the firm began producing the explosive tetranitroaniline (TNA) under contract with the U.S. government (in a new, government-funded building) as well as intermediates for dyes. After World War I, when sequestered German patents were made available through the Chemical Foundation (see *CH,* Fall 1998, p. 15), Calco and other American start-ups in the field of aromatic chemistry shared the spoils of German inventions and

A bird's-eye view of the Bound Brook factory from the northeast in 1940. Note the extensive parking area for automobiles in the foreground as well as the numerous buildings, most oriented in a north-south direction. From Dyes Made in America. *Courtesy of the Edelstein Collection.*



expanded their capabilities as they transformed patent recipes and new knowledge into useful products. The talented, ambitious, and forward-looking experts and entrepreneurs who presided over the Bound Brook factory began the large-scale manufacture of dyes and other products from their aromatic intermediates, drawing on this new knowledge as well as on their wartime experience with military-related technology and benefiting from the acquisition of the adjacent government TNA plant.

In the 1920s complex aromatic organic chemistry was new to the American chemical industry, and it required considerable scientific input. It involved multistep synthesis, starting with such coal-tar products as benzene and naphthalene. The need to enhance activity in this area explains why in 1927 a formal Research Department was organized out of the various uncoordinated R&D activities at Bound Brook.

Calco intended to dominate the manufacture of dye intermediates. When this failed, the firm turned to acquiring companies that made dyes different from those it manufactured (though from the same intermediates) and targeted to different markets, including paper and textile producers. Calco specialized in azo and triphenylmethane dyes, but soon turned to anthraquinone vat-dye manufacture. Despite a sometimes difficult learning curve, Calco persevered, and by the mid-1920s the Bound Brook site was by all accounts a pretty sophisticated, though struggling, factory. Much of this progress was achieved under the leadership of Calco's technical director, Victor Louis King, who "knew the purpose and location of every pipe in the plant."* (Before World War I, King's dexterity as a Ph.D. student had contributed to the Nobel Prize of Alfred Werner.)

Calco's expansion, however, was hampered by lack of funds and difficult trading conditions even before the Great Depression struck. The firm might well have collapsed but for its acquisition early in 1929 by the American Cyanamid Company, which was anxious to branch out from fertilizer manufacture, as recession had an increasingly negative impact on domestic agriculture. Calco became the dye-making hub for American Cyanamid, which purchased other, smaller, dye and pigment makers that were then brought under the control of the Calco subsidiary. The dye business remained tough, though there was a new use for Calco's aromatic intermediates in products for the tire industry, particularly at Goodyear, and American Cyanamid flourished during the Great Depression by supplying chemicals for use in gold extraction. These relative successes supported new ventures, most notably the development of sulfa drugs and amino plastics.

A display of numerous products showing the range of materials that could incorporate Calco dyes. "From delicate artificial flowers to tough battleship linoleum . . . the call is always for more color and better colors." Photo by Robert Coates; from Dyes Made in America. *Courtesy of the Edelstein Collection.*

Wonder Drugs: The Sulfa Story

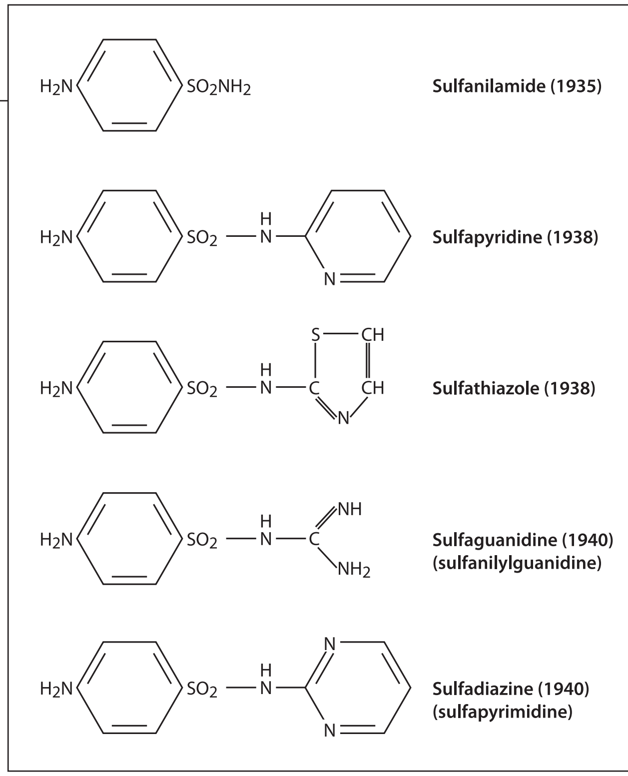
In 1930 American Cyanamid purchased the Lederle Antitoxin Company, a specialist in the production of biologicals. Under the American Cyanamid umbrella, Lederle and Calco subsequently collaborated in many areas, especially the development of sulfonamide drugs (sulfas), which relied on the technology of dye intermediates.

The sulfa drug story began in 1935, when Bayer in Germany introduced Prontosil, a sulfamido derivative of chrysoidine, a red azo dye found to be biologically active against streptococcal infections. French workers at the Pasteur Institute discovered that the curative agent was a breakdown product of Prontosil, *p*-aminobenzenesulfanilamide, or sulfanilamide. Because sulfanilamide had been described in a thesis in 1908 and therefore could not be patented, several companies undertook to manufacture and engage in

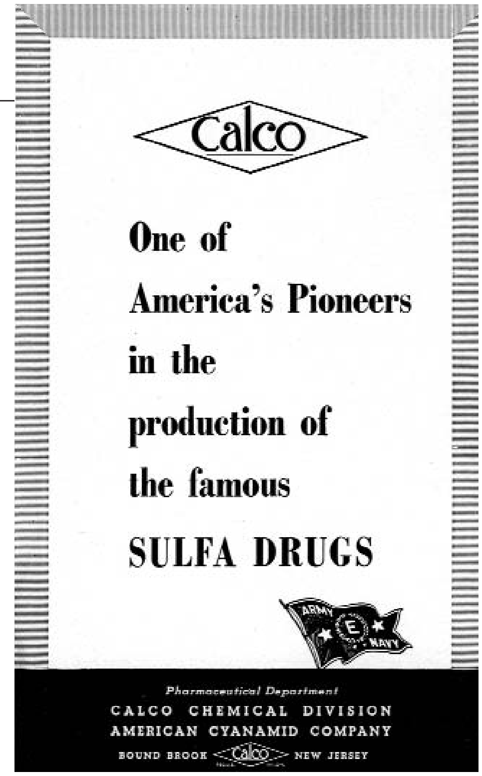
* Jay Leavitt, personal interview, 28 February 2001.

research on what became known as sulfonamide drugs.

Calco was the first American company to undertake this effort. Moses L. Crossley, an organic chemist in Calco's new pharmaceutical division, started research on sulfa drugs in June 1936, and a pilot plant for sulfanilamide was erected under the supervision of Elmore H. Northey, another organic chemist in the division. Calco's product received an unexpected—but very welcome—boost later that year when Prontylin, Winthrop Chemical Corporation's version of Bayer's original Prontosil, cured President Franklin Roosevelt's son of a throat infection. Calco dispatched research quantities of the highly effective sulfanilamide to physicians and medical researchers in the fall of 1936, and commercial delivery began in February 1937. Calco was the first American-owned firm to go into full production of sulfanilamide, and by July 1937 its output had reached nine tons annually.



Chemical structures of the early sulfa drugs.



Advertisement for Calco sulfa drugs, showing Army–Navy E pennant, with two stars. From "Special Issue, 108th Meeting American Chemical Society, North Jersey Section, September 11 to 15, 1944. Silver Jubilee, New Jersey Chemical Society," The Indicator *25:7 (September 1944), 31. Reproduced with permission of North Jersey Section, American Chemical Society.*

The next major discovery in this area was made at May & Baker, in England, where in the spring of 1938 sulfapyridine was synthesized. Sulfapyridine, which was highly effective against pneumonia, was also synthesized independently by a group of Calco-Lederle chemists, but it was produced at Bound Brook from 1939 on under license from May & Baker, which held the patent monopoly. Ironically, this new drug, which halved the death rate from pneumonia, was a setback for the new and expensive fermentation plant that Lederle had designed to produce pneumonia vaccines. May & Baker also discovered sulfathiazole, which was manufactured on a large scale from 1940 on in the United States by both Calco and Merck. Just as efficacious as sulfapyridine, it had the advantage of being less toxic.

At American Cyanamid, research into pharmaceuticals was generally conducted on two fronts, involving the facilities at Bound Brook plus either Lederle or American Cyanamid's new general research laboratories in Stamford, Connecticut, opened in 1937, where all therapeutic tests were conducted. R&D investigations at Bound Brook were similar to those carried out in dye research: products with characteristic arrangements of atoms or structural features were prepared and submitted for testing, an approach that was refined once the position of some grouping or property of the molecule appeared to offer promise. This meant that chemists steeped in dye chemistry could quickly move over to pharmaceutical research with hardly any change in technique or methodology. Indeed, as specific classes of compounds were modified, the products were screened for both biological activity and dye properties. If products appeared to offer potential as drugs and dye intermediates, care was taken to claim both in patent applications. Among compounds making the cut as drugs was the poorly absorbed sulfaguanidine, discovered in 1940 and introduced in 1941 following clinical studies conducted at Johns Hopkins Medical School. A patent for sulfadiazine, discovered in 1940 and "a sovereign treatment for pneumonia," enabled Calco to work on "an exclusive process." Sulfadiazine became particularly important when the United States entered World War II at the end of 1941, as large quantities of antibacterial drugs were needed to treat wounds and tropical and other illnesses in the armed forces.

By 1947 Northey and his colleague Martin Hultquist, sometimes with coworkers, filed over a dozen patents related to the synthesis of potential chemotherapeutic agents. At the close of the 1950s Bound Brook was the world's largest producer of sulfonamides, which, though eclipsed in human use by antibiotics (derived from living organisms), continued to be used extensively in veterinary fields.

Amino Plastics

World War II also required plastics and resins for laminates and adhesives, and American

This display of colored disks shows the range that American Cyanamid achieved in its melamine plastics. From Dyes Made in America. *Courtesy of the Edelstein Collection.*

Cyanamid and Calco were ready. Production of urea-formaldehyde and melamine-formaldehyde resins at Bound Brook represented a remarkable merger of the technical capabilities in organic chemistry at Calco and in inorganic chemistry at American Cyanamid.

During the 1920s and 1930s Cyanamid undertook research into urea-formaldehyde condensation products: novel polymeric resins. The firm's entry into the polymer field relied on an English innovation at British Cyanides (later British Industrial Plastics, now BIP), of Oldbury, near Birmingham, based on urea-thiourea-formaldehyde resins. These were known as Beetle (from "beat all") resins, and their popularity stemmed from the ease with which they could be molded into colored household items and other objects. British Cyanides assigned rights for their manufacture in the United States to American Cyanamid in May 1929.

The cover of British Plastics *for April 1934 featured Beetleware, bright molded plastic that Calco sought to emulate and surpass. From the Edelstein Collection, Hebrew University.*

In the 1920s the demand for plastic materials had in part been satisfied by Bakelite, obtained by the reaction of phenol with formaldehyde. Bakelite plastics, however, had one big disadvantage: the colors were limited to brown or black, though the 1930s did see the development of some colored Bakelites, often through the incorporation of Calco pigments. Bakelite's appearance was also considerably enhanced by Calco nigrosine blacks. While this limitation on color may have suited the automobile and electrical industries, it slowed expansion of the range of household products.

British Cyanides worked out an alliance with American Cyanamid by which the Synthetic Plastics Corporation, a Cyanamid subsidiary, made aminoplastic products at Calco. Colored plastics, molded into various shapes and moderately priced, were now available for the first time. Bound Brook chemists quickly changed the formulation to straight urea-formaldehyde, thus overcoming the need to synthesize expensive thiourea. American Cyanamid created Beetleware Corporation, a new subsidiary linked with Synthetic Plastics, to produce colored tableware from the amino resin. Urea-formaldehyde resins were modified for use as laminating resins, and toward the end of the 1930s a line of resin adhesives was introduced during World War II for use in the construction of aircraft and boats.

American Cyanamid was to become synonymous with its next major advance: the production of melamine and of the polymeric products named after it. The triazine compound melamine (2,4,6-triamino-1,3,5-triazine) was first isolated and named by Justus Liebig in 1834, and the triazine structure was established in 1902. Although various industrial reactions for preparing melamine had been patented in Europe, the industrial process was perfected in 1939 at Bound Brook by Calco's technical director, Victor King, and Carl Mensing, the director of engineering. The process started, significantly, with American Cyanamid's own calcium cyanamide, which was converted into dicyandiamide and then into melamine. The latter reacted with formaldehyde to produce a product similar to Beetle. During 1943, production of melamine resins reached 40,000 tons, all used for military purposes, ranging from protective laminates to unbreakable plates.

The melamine resins, similar in many respects to the urea-formaldehyde condensates, displayed greater resistance to moisture and heat. The melamine molding product sold after World War II under the trade name Melmac represented a tremendous advance in aminoplastics and, because of its superior molding and mixing properties, for certain purposes superseded aminoplastics based on urea. After World War II, Melmac was adapted for use in plastic tableware and became associated with the names of such leading industrial designers as Russel Wright, Raymond Lowey, and Kate LaMoyne. There were 2 molders of melamine dinnerware in 1946, 11 in 1948, and 14 in 1950; by mid-century these products were popular in hotels and restaurants. In fact, Melmac's popularity as dinnerware lasted for decades, with new designs appearing into the 1970s. Melamine was also used in the laminates in tabletops and countertops produced by the Formica Insulation Company.

Epilogue

American Cyanamid's Bound Brook dye-making facility was in many respects atypical. Structurally and organizationally it had progressed from an outfit that mainly manufactured intermediates to an integrated chemical city involving every stage from research to a range of services to users of its products. It was exceptionally innovative, even if, as former R&D manager Jay Leavitt put it, in "a copying sort of way."* In 1934, reflecting the high status and great investment opportunities then enjoyed by large chemical firms, American Cyanamid had moved its corporate headquarters from Niagara Falls to the top floors of the new RCA Building in New York's Rockefeller Center, which offered greater access to Wall Street capital for much-needed expansion.

Dyes, melamine resins, and sulfa drugs made American Cyanamid and its Calco division one of the wonders of research-led corporate America. Through the focus on dyes and intermediates and the efforts of such physicists as Edwin Ira Stearns, Calco also became a world leader in physical instrumentation, particularly spectrophotometry, and pioneered instrumental color standardization and color matching for dyestuffs. Such was the status of Bound Brook scientists in the international dye industry that for several years its scientists dominated the American editorial board of the dye-makers and dyers' bible, the *Colour Index*.

The so-called wonder drugs and novel plastics, including products that had been developed during World War II and that were adapted for the civilian economy, maintained the aura that kept the chemical industry in the spotlight for another decade. In 1954, in a major reorganization, the Calco Chemical Division became the largest component of American Cyanamid's new Organic Chemicals Division. Modern research, development, and technical service laboratories were opened at Bound Brook.

Overall, the Calco–American Cyanamid story is certainly one of success, mirroring the remarkable early-20th-century rise of the U.S. dyestuff and organic chemical industry. From the 1960s onward, though, the chemical industry was plagued by a lack of clear vision, particularly regarding long-term research, that resulted in a two-decade hiatus in completely new innovations. Reliance on profits from existing lines that were once novelties but had become staple commodities, sometimes labyrinthine corporate bureaucracies, and—particularly at Cyanamid—the sacrifice of individual creativity to short-term profitability all combined to diminish the standing of industrial chemistry. In 1962 the American Cyanamid corporate headquarters moved to Wayne, New Jersey, and the company's decline continued in the face of heavy competition from imported products, premature modernizations based on computerized and continuous processes, and—especially after 1970—increasingly stringent environmental regulations.

Around 1980, following international trade negotiations, most American firms cut back on dye production, sometimes by selling dye-making units to foreign-owned competitors in the United States, and changed focus altogether. By the 1980s American Cyanamid's operations were fully concentrated on the life sciences, and in March 2000 BASF bought the American Cyanamid name and its agrochemical businesses. The Bound Brook facility, site of so many innovations and of Paul Robeson's visit decades earlier, saw its manufacturing buildings demolished by around 2002 as it became just one more of the many vanishing industrial sites where once the foundations of the modern American organic chemical industry were laid.

* Jay Leavitt, personal interview, 28 February 2001.

For Further Reading

Lutz, Albert W. *Agricultural Research at American Cyanamid: From Calcium Cyanamide to CYDECTIN.* Princeton, NJ: American Cyanamid Company, 1993.

Travis, Anthony S. *Dyes Made in America, 1915–1980: The Calco Chemical Company, American Cyanamid, and the Raritan River.* Jerusalem: Edelstein Center; Hexagon Press, 2004. Distributed by Jeremy Mills Publishing Limited.

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