ABSTRACT
The modern U.S. chemical industry emerged during World War I in response to shortages of essential organic chemicals previously mainly from Germany. These chemicals were the coal-tar intermediates and their derived products, mainly dyestuffs and pharmaceuticals. This stimulated the development of technologies based on complex aromatic chemistry as well as the inauguration of sophisticated research programmes in industry. The outcome was an advanced science-based industry that embarked on diversification during the 1920s. However, access to German innovations was still needed, and the Germans wished to regain dye markets lost during the war. This led to a singularly important merging of American and German interests, the General Aniline Works, later known as General Aniline & Film. Under German ownership in the 1930s, a unique strategy for control of production and research was implemented at General Aniline. Under U.S. government ownership from 1942, General Aniline engaged in diversification based on pre-war German innovations made at I.G. Farben. The cessation of dyestuff manufacture in the 1970s at what had become the GAF Corporation represented a break with the past that was also taking place elsewhere in the United States. A half a century after its foundation the classical organic chemical industry had become an anachronism.

INTRODUCTION
In July 1977, the U.S. chemical concern known as the GAF Corporation, formerly General Aniline & Film, announced plans to exit the consumer photography market. Financial analysts were hardly surprised since GAF’s photo products group had lagged behind Kodak for many years and lost $3 million in 1976. Historically more significant, however, were a few words buried below the headlines-making announcement stating that the dye business, once the very foundation of the company, would also be dropped. GAF thus became the second of the major U.S.-based dye manufacturers to quit the sector that had launched the synthetic organic chemical industry in the World War I era. Allied Chemical had left the market earlier in 1977, and Du Pont and American Cyanamid would soon follow. In an ironic turn of events, a large share of the U.S. dye industry was now dominated by German companies whose imports the American producers had struggled to replace during the World War I dye crisis. Among those early producers was the Grasselli Chemical Company, forerunner of GAF.

Grasselli Chemical Company
The origins of the GAF dyes business, with major plants near Linden, Union County, New Jersey, and at Rensselaer, New York State, lay with the Grasselli Chemical Company, founded by Eugene R. Grasselli in 1839 in Cincinnati, Ohio. Grasselli Chemical produced heavy chemicals such as the mineral acids oil of vitriol (sulphuric acid), nitric acid and muriatic (hydrochloric) acid, and later moved to a new plant in Cleveland to be closer to sources of raw material and the main consumers, the oil refiners. When Grasselli died in 1882, his son Caesar A. Grasselli (Figure 1), a young chemist, took over the company and within a few years implemented an ambitious growth plan.
In 1889, Grasselli Chemical purchased the Standard Chemical Works, situated near Linden, New Jersey, on the Tremley Point peninsula, close to where the Arthur Kill and Rahway River converge and flow towards Raritan Bay and the Atlantic Ocean. The Standard Chemical site included around 300 acres of a marshy area with a mile and a half of waterfront and a barge dock on the Arthur Kill. The main product at Tremley was sulphuric acid, used in large quantities by the local oil refineries.

Grasselli Chemical diversified in both inorganic and, later, organic chemicals. For example, acetic acid manufacture was added to the list of Tremley products not long after 1900. Another area of interest involving organic chemicals was that of accelerators used in vulcanization of rubber that enabled restoration of elasticity following deformation. This followed George Oenslager’s discovery in 1906 at Diamond Rubber that aniline, its derivative thiocarbanilide, and related organic chemicals containing sulfur, accelerated the vulcanization of rubber. Grasselli Chemical entered this business after 1910 when it acquired the patent of F. Hoffmann and K. Gottlob, who found that ammonium dithiocarbonates made from both aromatic and aliphatic amines were also good vulcanization accelerators.

By 1915 the Grasselli Chemical Company had assets of around $30 million and operated eight manufacturing plants and six warehouses in eastern and mid-western states. Earnings in 1915 were $4.9 million or 38 per cent on common stock and the earnings forecast for 1916 was 100 per cent on common stock. The company’s strong financial position, and the changes brought about by the war in Europe, enabled it to consider a tantalizing investment opportunity, the manufacture of synthetic, or coal-tar, dyestuffs. The main encouragement to Caesar Grasselli came from Dr. Adolph Wack, a chemist at the Verona Chemical Company, that produced coal-tar intermediates in Newark.

Prior to the onset of World War I, Germany and, to a lesser extent, Switzerland, supplied most of the dyes needed by the textile, paper, leather, ink and varnish industries in the United States. The dye shortage caused by the British blockade of German shipping, and German restrictions on exports, caused a panic in the market and inflated prices to record levels. In 1914, there were just seven domestic firms making a limited range of colours, mainly from imported intermediates. The third largest manufacturer, and certainly one of the most efficient, was the German Bayer Company, on the east bank of the Hudson River at Rensselaer. The total U.S. dye output was only 6.6 million pounds with a value of US$2.4 million. Including imports, the annual dye consumption in the United States was estimated at US$15 million. Since domestic firms supplied a fraction of the demand, there was from early 1915 an urgent need for increased U.S. production. Like several other entrepreneurs, Caesar Grasselli went into the business with some hesitation, aware of the risks involved in entering a field in which he had no experience. He chose the Tremley site, near Linden, for his new enterprise.

Grasselli Chemical built its new dyes plant in the western portion of the portion of the Tremley site, an area separated from the heavy chemicals plant to the immediate east by the tracks of the Jersey Central Railroad. To ensure a permanent labour force, Grasselli Chemical began the construction of 300 one-storey homes to house workers. The community was divided by a wide, tree lined Main Street into two ethnic sections: Grasselli Park, housing Irish and English families whose men were supervisors, and Tremley, whose residents were mainly Polish and Slovak immigrant workers, attracted by the opportunity to have their own homes and good paying jobs. The dye plant and the surrounding industrial area was known as Grasselli, which was also the local railroad station and the main road leading to the plant. However, the
Grasselli Chemical site was often referred to as Linden.

Sulphur dyes, mainly the large volume sulphur blacks for the cotton and hosiery trades, were the first dyes produced in 1915. This was a wise decision for a company new to the dyes business, since sulphur dyes were relatively easy to produce in simple equipment in which mixtures of aromatic compounds such as dinitrophenol and aniline were baked with sulphur. The chemistry of sulphur black was obscure, so its manufacture relied more on craft than science, particularly careful control of temperature and time. The copious evolution of hydrogen sulphide and ammonia ensured that the working conditions were hardly salubrious. Sulphur black was a commodity with 5.6 million pounds imported in 1914. There were only two other producers, both in New York, in 1915: Schoellkopf Aniline & Chemical Works, in Buffalo, and Standard Aniline Products, in Wappingers Falls. The calculated risk soon paid off: In 1914, sulphur black had sold for about US$0.20 per pound; during 1915 the price soared to US$2.75-3.00 per lb.\(^1\)

As soon as the United States entered World War I in April 1917 there was a tremendous demand for dyes of khaki shades. The plans for an army of one million men in uniform made necessary 30 to 40 million yards of cotton khaki shirts and mixed meltons (wool/cotton blends) for tunics and overcoats. The military also needed an olive drab coloured uniform to help soldiers blend in with their surroundings in the European battle grounds. Prior to 1914, dyes for military uniforms were obtained from Germany. Apart from synthetic indigo, they included vat, or Indanthrene, dyes. The latter were based on derivatives of anthraquinone, the basis of the important red colorant known as alizarin, and developed from 1901 at Badische Anilin- & Soda-Fabrik (BASF) and Bayer. Vat dyes passed the stringent fastness tests set by the military, including fastness to light and to harsh chemicals such as acids and bleaches. Since vat dyes were no longer available in the United States, the military relaxed the fastness tests, requiring only a thirty-day light exposure and fastness to soap and alkali.\(^12\) This decision was a boon to makers of sulphur dyes that could also produce khaki shades, and no doubt provided the incentive for Grasselli to further enlarge the business. The expansion continued after Caesar Grasselli handed over management to his son Thomas S. Grasselli, in 1916.

While German chemists in America were considered to be high security risks in industry, this was not the case for Swiss chemists. In September 1918 Dr. Edwin A. Meier, a Swiss chemist previously at Standard Aniline where he supervised the manufacture of intermediates and sulphur dyes, particularly sulphur black, was hired as plant chemist at Linden. Meier brought with him the valuable dye-making experience that most American chemists lacked at the time.\(^13\) The sulphur dye range was expanded to include not only khaki, tan, brown, and olive, but also yellow brown, red brown, and orange shades.\(^14\) Also in 1918, Linden introduced its first alizarin dye, alizarin blue, for wool, manufactured in two steps from alizarin, a derivative of anthraquinone, that was made from coal-tar anthracene. The intermediate compounds were made from primary coal-tar intermediates such as nitrobenzene, aniline, phenol and anthraquinone, available from Verona and other chemical firms that had sprung up in New Jersey, New York, and Pennsylvania.

The Bayer Rensselaer Plant Acquired

The strong demand for dyes and the high selling prices during the war guaranteed profits to a company willing to put up the capital needed to acquire relevant knowledge and skills. Grasselli Chemical decided that one way of doing this was to purchase an existing business. A prime candidate became available, although only after hostilities had ceased. This was the Bayer plant at Rensselaer, located 140 miles north of New York City, which produced dyes and pharmaceuticals such as Aspirin and phenacetin. It had been established as the Hudson River Aniline & Color Works in 1882, and was successor to the Albany Aniline & Chemical Company, founded in 1868 by Arthur Bott, a manufacturer of colored paper and cardboard.\(^15\) Bayer initially held a 25 per cent interest in the Hudson River concern, that by the turn of the century was managed by the Swiss chemist Emmanuel von Salis, who had worked in England. (Figure 2, Figure 3) Dr. Carl Duisberg, head chemist at Bayer, visited the site in 1903 and recommended it as a manufacturing location for Bayer’s pharmaceutical products, especially aspirin.\(^16\) The company became a fully-owned subsidiary of Bayer in the same year.
Figure 2. Hudson River Aniline and Color Works, ca. 1915. Photo Courtesy Bayer AG

KEY

Construction and expansion dates for major Hudson River Aniline Works buildings:
41 1917 Production. 61 1882, 1895, 1905 First production and office building. Rebuilt in 1895 after fire destroyed original building. 64 1917 Ice plant. 65 1908, 1916, 1948 Power plant and utilities. 67 1915 Maintenance and machine shop. 68 1915, 1918 Production. 69 1915, 1936 Store area. 71 1895 Office and laboratory. 72 1905 Electrical maintenance shop. 73 1905, 1915 Drying of dye presscakes. 81 1918, 1944 Production. 83 1916, 1933, 1935, 1932 Production of azo dyes. 85 1917 Production. In 1919, Sterling Drug acquired the area to the north, beyond the fence at left.

Construction and expansion dates for Grasselli Dyestuff Corporation, General Aniline Works, General Aniline & Film major buildings:
62 1929 Storage of acid and caustic soda. 75 1932, 1935-36, 1941-42 Analytical research and dye laboratories, production management, accounting, etc. 82 1928, 1938 Production. 84 1926 Production. 86 1927, 1928 Production. 88 1935-36 Milling equipment for finishing of powder dyes. 89 1930, 1938, 1941 Warehouse. 91 1933-34 Main gatehouse, hospital and cafeteria. 93 1946 Main drying facility. Building 87, dating from 1946, was the largest production building constructed under US government ownership. Warehouse 39, erected by Sterling-Winthrop in 1946, was acquired by BASF in the late 1980s to replace 89.
Figure 3. Plan of the Rensselaer Site under ownership of Hudson River Aniline & Color Works (1882), Grasselli Chemical Company (1919), Grasselli Dyestuff Corporation (1924), General Aniline Works (1928), General Aniline & Film (GAF) (1930), and BASF (1978–2000). Photo inset is the facility around 1940. Edelstein Collection.

It was also in 1903 that New York State health officials began to link pollution of the Hudson River with outbreaks of typhoid and other water-borne diseases. A pollution survey was conducted and more than 800 factories responded, including the Hudson River Aniline & Color Works. The Rensselaer plant discharged directly into the Hudson River 5000 gallons daily of a toxic mixture of aniline oil, hydrochloric acid, sulfuric acid, dinitrobenzene and raw sewage from its 33 employees. The survey provides a glimpse of the environmental problems that would always taint the dye industry’s public image and in part contribute towards its demise after 1970.

Pharmaceutical manufacturing buildings were erected at Rensselaer in 1905 in the northern portion of the site. Dye capacity was increased at the same time, and more substantially from 1913. By 1914 the Rensselaer plant was the third largest producer of dyes in the United States, with a 17 per cent market share. The product line consisted of staple dyes, all invented before the mid-1870s, for the paper and leather industries: indoline, nigrosine, fuchsine, alkali blue, soluble blue, and the azo dyes Bismarck brown and chrysoidine (Figure 4). Textile dyes, many of more modern origins, particularly the vat dyes, were imported from Bayer, an arrangement dating back to the 1890s. A novel product made at Rensselaer was Monopole Brilliant Oil, an early synthetic detergent for the textile industry, made by sulphonating castor oil. It had a higher degree of sulphonation than an earlier product known as Turkey Red Oil, affording superior wetting and dispersing properties in hard water.
The master plan drawn up by Bayer for the Rensselaer site envisioned the largest and most modern chemical plant in the United States, closely modeled on the lines of the new Bayer Leverkusen factory in Germany, and employing almost 8,000 people. The planning, however, was abruptly terminated with the onset of World War I. Dye production, based on imported German intermediates, almost ceased. The Rensselaer plant lay idle for several months in 1915, but resumed production later that year with intermediates produced on site. Several textile dyes that were previously imported were also now made at the plant, particularly the alizarin and azo colours, under the continued management of von Salis. The improved financial position enabled this U.S. operation of the Bayer Company to earn US$1.5 million annually by 1917.

After the United States declared war on Germany, the assets of the Bayer Company were seized, including offices and warehouses, the Rensselaer plant, and patent rights. In late 1917 Federal Judge A. Mitchell Palmer, the Alien Property Custodian, announced his intention to ‘thoroughly Americanize’ the company and named four new members to the board of directors. One of them was von Salis.

Anti-German hysteria and tales of German conspiracies, real and imagined, were prevalent in wartime America, and affected the Rensselaer plant. The Alien Property Custodian claimed to have uncovered a conspiracy involving members of the previous management still on the board who violated the Trading with the Enemy Act. In August 1918 five company officials were arrested and charged with diverting profits to a dummy corporation in Rhode Island and thence to Germany. The purpose was to enable Bayer to reestablish its dyes and pharmaceuticals business in the United States when the war ended. The men arrested were Herman C. A. Seebohm, director and secretary; Dr. R. J. Pabst, manager of sales; A. Reiser, manager of the Williams & Crowell Color Company of Providence, Rhode Island; Dr. Albert Segin, head of pharmaceuticals; and Dr. Rudolph Hutz, a former company director and manager of the Boston sales office. At the time Hutz was staying at his summer home on Pine Island, Lake Winnipesaukee, New Hampshire. Secret Service agents found a boat and rowed out to the island to make his arrest at 1:30 AM. He was charged with violation of the Trading-with-the-Enemy Act and espionage and was interned at Ellis Island. The dramatic arrests were followed with the firing of any Rensselaer plant employee suspected of sympathizing with Germany. Rumours that Aspirin was formulated to cause flu outbreaks were spread. This situation accelerated efforts by the government to sell the company to an American firm.

In December 1918 the Alien Property Custodian held an auction of Bayer assets on the steps of the Rensselaer plant office. Representatives of over one hundred American chemical and pharmaceutical companies attended. The winning bid of US$5.3 million came from the then relatively unknown Sterling Products Company, a pharmaceuticals firm based in Wheeling, West Virginia. Sterling Products was interested only in the pharmaceuticals business; its bid was made in conjunction with Grasselli Chemical that in 1919 paid Sterling US$2.5 million for the dye section. The Rensselaer site, now occupied by two separate companies, Sterling and Grasselli, was far more compact than Tremley. It covered 75 acres of land and consisted of 20 manufacturing buildings. The location along the Hudson River, southeast of the Port of Albany and adjoining the railroad tracks to the east, expedited the shipping of both raw materials and finished products. Coal for the power plant could be delivered by either rail or barge.

Two-thirds of the Rensselaer production area was dedicated to dyes manufacturing. In order to supply the heavy demand for dyes during the war, several new buildings had been added in the 1915-17 period: an intermediates unit for nitrobenzene, dinitrochlorobenzene, dinitrotoluene and aniline oil, among others; an azo dye unit; a production unit for wool green, the company’s first triphenylmethane dye; a boiler room and smoke stack; and an ice making unit. Acetic anhydride was made for pharmaceuticals production. Basic raw material and
mineral acid capacity was also put in place, with units producing nitric, sulphuric and hydrochloric acids. This was a strategic advantage since commercial acids were in tight supply due to war production requirements, particularly of nitric and sulphuric acids, required in nitration of aromatics for explosives manufacture.

After the war the market for dyes declined sharply along with the selling prices. The Rensselaer acquisition became a financial burden for Grasselli Chemical. Plans for further expansion of the plant were cancelled and cost-cutting measures were introduced. Maintenance spending was reduced and the plant and equipment rapidly deteriorated.29

The financial situation was made more difficult because Grasselli Chemical was a novice in dye manufacturing and faced a know-how gap when compared to its more experienced competitors. Thus the production of intermediates at Linden in 1920, some 114,000 lbs., represented just five products, notwithstanding the fact that the company had obtained the rights to 1200 German patents on dyes, intermediates and related chemicals, many through the purchase of Rensselaer. The German patents, however, did not provide sufficient details to enable replication of the inventions claimed. This situation existed elsewhere, to the extent that Du Pont went as far as spiriting four dye chemists out of Germany in 1920. ‘An ordinary chemist couldn’t work the patents,’ claimed Ireen du Pont, then Du Pont's president.30 Grasselli Chemical realised that it lacked the specialized knowledge to commercialize the dye patents and expand the product line beyond the staples that competitors were also making. It was time to turn to the dye industry of the former enemy nation.

Before the war, Caesar Grasselli had met with Carl Duisberg, now the head of Bayer, on his visits to the United States. This connection now led to a suggestion for a merging of their interests in the dye-making sector in America. A telegram was sent on 14 August 1919 to the Bayer headquarters in Leverkusen, suggesting a meeting ‘to discuss matters of mutual interest.’31 Though Grasselli was prepared to offer a joint venture proposal, Bayer did not respond immediately in order to avoid giving the impression of officially recognizing the seizure of its U.S. assets.32

Around this time Grasselli Chemical established a research department at Linden under a German chemist, Dr. F. Reichel. This group soon consisted of ten chemists, but during the recession of 1921-22 the department was abandoned. From that time research was carried out within individual manufacturing departments, aided by a general analytical laboratory opened in 1921. There was a significant input from a Grasselli-owned laboratory in Geneva, Switzerland. There, Hans Heer, educated at the Swiss Federal Polytechnic, in Zurich, from October 1920 undertook research on alizarin dyes. At that time one alizarin colorant, alizarin blue, was made at Linden, by nitration of alizarin, to afford alizarin orange A, that with glycerol in the presence of sulphuric acid gave the blue. Investigations, probably mainly with alizarin blue, led to the discovery of other alizarin dyes. During three years, Heer developed new processes, and in 1923 was moved from Geneva to Linden, where he was appointed laboratory chemist in the Alizarine Department.

The recession had considerably worsened the financial position of Grasselli Chemical. The average selling price of U.S. made dyes dropped from US$1.26 per pound in 1917 to US$0.83 in 1921, a 34 per cent reduction.33 Rumours circulated about the company going out of the dye business. In early 1922, Grasselli, along with other U.S. dye-makers, took its case to Congress and strongly supported the enactment of a protective tariff against foreign competition. William T. Cashman, vice president, testified at a Congressional hearing that the company had invested US$4.5 million in the dyes business but was losing money. Cashman said that no additional capital had been put into the business in the previous two years because of the uncertainty of Congress supporting the domestic industry. He cited the fierce competition among American producers of wool green and nigrosine dyes to counter any allegations of a dye monopoly.34

The Fordney McCumber Tariff Act, passed in 1922, helped the domestic dye industry by introducing high tariffs and anti-dumping fines on coal-tar chemicals and dyes that competed with products made in America. The ad valorem rate on dyes and finished coal-tar products was 60 per cent; on intermediates the rate was 55 per cent. These rates applied for the first two years after the passage of the act and then decreased to 45 per cent and 40 per cent, respectively. The specific duty was US$.07 per lb. The ad valorem rate was based on the American selling price of competing products.35

The I. G. Farben Influence
Now that the tariff barrier was in place Grasselli Chemical was in a far stronger position to seek financial and technical assistance from Bayer through a joint venture. Bayer was receptive since it was eager to reestablish dyes manufacturing capacity in the United States mainly to overcome the burden imposed by the tariffs. However, Bayer was a member of the dye cartel Interessengemeinschaft der deutschen Teefarbenindustrie. Though Grasselli Chemical strongly denied that it intended to sell its plants to members of the German dye cartel the negotiations sparked rumours of a German invasion of the American dye industry. After lengthy negotiations, Grasselli came to a collaborative agreement with Bayer in June 1924 to form the Grasselli Dyestuff Corporation, as operator of the Linden and Rensselaer dye plants and sole distributor of Bayer dyes in the United States. Grasselli Dyestuff, in which each company had a 50 per cent share, was incorporated in Delaware with a capital of US$4.0 million. The main office was in New York City and the officers were G. E. Fisher, president; Edward W. Furst, vice president; Dr. Roger N. Wallach, vice president and treasurer; and Rudolph Hutz, vice president and secretary. Fisher and Furst were vice presidents of Grasselli Chemical. Wallach and Hutz came from the dyes department of Grasselli Chemical. Wallach was previously technical director of Standard Aniline Products, that had shut down in 1919. Hutz, the former Bayer official arrested during World War I, had been released after the Armistice was signed and then joined Grasselli Chemical.

Grasselli Chemical and Bayer assigned all present and future patents to Grasselli Dyestuff and it was agreed that the new corporation would forego exporting its own manufactured dyes except to Canada. The Grasselli Dyestuff Corporation had its own sales and technical organizations, though these functions were soon taken over by the General Dyestuff Corporation (hereafter GDC), formed in July 1925. This new sales organization was headed by veterans of the imported dye business: Adolph Kuttroff, chairman of the board; Herman A. Metz, president; and Ernest K. Halbach, the dynamic secretary and general manager who later controlled GDC and acquired a major interest in the Verona Chemical Company. GDC had the American selling rights for the largest German dye producers, Bayer, BASF, and Hoechst, that merged to form the behemoth I. G. Farben in 1925 (later absorbing Agfa, Griesheim-Elektron, and Weiler-ter-Meer). The Grasselli Dyestuff Corporation continued only as a manufacturer. The German connection meant that Grasselli was removed from membership of the Society of Organic Chemical Manufacturers, a US association of chemical companies.

Grasselli Dyestuff and GDC fitted in well with the I.G. Farben strategic plan for global expansion launched through business combinations, often involving exchanges of strategic knowledge, and takeovers (Figure 5). The tremendous potential for growth in the United States was of paramount importance to this plan, that is best known for the collaborative agreements with Standard Oil of New Jersey over coal-to-oil conversion and synthetic rubber. Outside the United States, where strong antitrust laws existed, the type of collaborations were generally different, often relying on cartels involving dyestuffs and nitrogen products. The close involvement of I. G. Farben in Grasselli Dyestuff resulted in an infusion of capital and the transfer of German technical personnel to modernize and expand the two facilities. This strategy was endorsed by Fritz ter Meer, a member of the board of directors in charge of dyestuff production who visited the United States in 1926. To direct the reorganization at Rensselaer, Dr. W. Walther was sent over from Leverkusen. New equipment was added, production processes were improved, and new products were introduced. Walther was succeeded by Dr. C. C. Burgdorf, also from Leverkusen, who concentrated his efforts on improvements at the Linden plant. Rensselaer still needed technical assistance, so Burgdorf asked Leverkusen for help. In 1926, Dr. Harry W. Grimmel was sent over, replacing von Salis as general manager. By 1927 the Rensselaer staff had increased to 311 employees: seven chemists, two engineers, a colorist, 15 foremen, and 286 workers.
Figure 5. General Dyestuff Corporation advertisement for Fast Color Salts. Dyes initially manufactured in I.G. Farben plants in Germany were transferred to the Grasselli Dyestuff plants in the U.S. American Dyestuff Reporter Sample Swatch Quarterly, October 15, 1928.
**Naphthalene Intermediates**

A formal Intermediates Department was created at Linden in 1925 to coordinate growth of the product line. In the same year construction began on the first of a series of substantial new buildings, No. 46, for the production of intermediates. The most important of these were the “letter acids” derived from beta-naphthol, such as H-acid (1-amino-8-hydroxynaphthalene-3, 6-disulphonic acid), Gamma acid (2-amino-8-hydroxynaphthalene-6-sulphonic acid) and, later, R- and S- acids. (Figure 6) The letter acids were shipped to Rensselaer for the production of direct dyes, water-soluble azo dyes with good affinity for cotton and rayon. The manufacture of H-acid, a complicated multi-step process, had been attempted in 1918 at Rensselaer but was then unsuccessful.\(^{40}\) The process used by the Linden plant in the 1920s likely began by sulphonating naphthalene to form naphthalene-1, 3, 6-trisulphonic acid, which was then nitrated, reduced with iron in hydrochloric acid, and finally fused with caustic soda.

![Figure 6. Production of Letter Acids from beta-Naphthol. Image: Travis, Dyes Made in America 1915-1980.](image)

Dr. Nathan Fuchs, who joined Rensselaer in 1925, undertook intermediates research at Linden from 1927, in which year J. Albert Prochazka was engaged in the production of naphthylamine intermediates in building No. 46. Heavy demand meant continuous operation in the intermediates buildings, based on two shifts, one during the day of ten hours, the other at night of fourteen hours.

**Azoics**

In the 1920s the textile industry began to expand the use of the new azoic dyes for dyeing and printing of cotton and rayon. Azoics are azo dyes which are not applied directly but actually produced within the cellulose fibre. This was done by padding the fibre with the coupling component of the dye, followed by treatment with the diazo component, thus forming the dye within the fibre. The insoluble dye was very fast to washing. The azoic dye process gave the textile industry a complete range of bright shades with excellent fastness properties.

The development of the U.S. market for azoics demonstrates how I. G. Farben dye patents were commercialized in the United States through initial importation of dyes and certain intermediates, thus preventing disclosure of valuable proprietary information about both products and processes. Griesheim-Elektron, one of the smaller members of I. G. Farben, had discovered in that Naphthol AS (3-hydroxy-2-naphthoic acid anilide, Figure 7) gave fast shades when coupled with various diazo components on cotton.\(^{41}\) GDC began importing the azoic dye components from Germany in 1925. Griesheim supplied the coupling components: Naphthol AS and seven congeners. Bayer Leverkusen supplied 16 different diazo components, or bases, such as Fast Red G (meta-nitro-para-toluidine). Once the azoics market was well established with the imports, the Grasselli Dyestuff plants began domestic manufacture of the components. The Naphthol AS components were made at Linden.

![Figure 7. Naphthol AS Coupling Component for Azoic Dyes](image)
‘Fast color salts’ and New Dyes

A significant technical advance soon followed, the so-called ‘fast color salts’, diazos prepared in stable powder form. As a result, the dyer no longer had to diazotize the base with nitrous acid in ice, a difficult and time consuming procedure in a textile mill. The fast color salts were simply dissolved in water and applied to the naphtholated fabric under slightly acid conditions. The dry diazo salts were stable for years and their solutions could be kept much longer in a mill than a normally diazotized base. In 1927 the Rensselaer plant became the first in the United States to produce fast color salts and later produced the rapid fast colors as pastes that further simplified the dyeing procedure. These paste products were mixtures of the sodium salts of naphthols with the nitrosamines of bases, held in a strong alkaline medium to prevent coupling. The dyer only had to add a weak organic acid to the printing paste. This converted the nitrosamine to the diazo, which immediately coupled with the naphthol to form the dye.

New dyes in the Rensselaer product line included triphenylmethanes, azines, acridines, euchrysines and phosphines. Many were basic dyes used to dye wool, silk and paper bright shades from an acid bath. Linden further expanded with a $200,000 engineering building, No. 47, completed in 1928. The first head of engineering was John Newman, replaced in 1923 by Charles B. C. Fellows, and then in the 1930s by Franz Brandt and H. P. Angermueller, sent over from BASF at Ludwigshafen, along with another engineer named Kropp. Buildings at Linden, arranged in ordered rows, were erected on deep piles, and were open below the ground floor in order to minimize damage from frequent floods that inundated the plant. Together, the Linden and Rensselaer plants now offered an impressive list of 250 dyes.

In 1928, the Grasselli Chemical Company was purchased for $64.8 million in stock by Du Pont, that took over the heavy chemicals section of the Linden plant and sold Grasselli Dyestuff, that occupied the so-called West Works, and owned Rensselaer, to I. G. Farben. The name of the business was then changed to the General Aniline Works, Inc. Dr Ferdinand Max was sent from Ludwigshafen to Linden where he was appointed general manager and assistant vice president of the General Aniline Works. His transfer continued I. G. Farben’s strategy of placing its best technical employees in leadership positions in the United States in order to facilitate technology transfer, protect strategic knowledge, and strengthen its position as a domestic manufacturer. Du Pont was not interested in forming an alliance with I. G. Farben, but maintained a friendly relationship. This included the supply of cooling water to the Linden dye factory.

Anthraquinone vat dyes

Though the General Aniline Works had a diverse product line, vat dyes, one of the fastest growing classes, were excluded, in part because they were imported from Germany. Vat dyes, which include indigo and anthraquinone-based dyes, are insoluble in water. They must first be reduced to the leuco form in an alkaline solution of sodium hydrosulfite before application to the cotton or rayon fibre. Air oxidation fixes the dye on the fibre, resulting in excellent wash fastness and light fastness. Although the vat dyes were costly to manufacture due to their chemical complexity, they were in great demand in the USA for heavily laundered items like denims, shirts, and bed linens and outdoor fabrics such as awnings.

Indanthrene blue was the first anthraquinone vat dye, synthesized by René Bohn at BASF in 1901. He used the synthetic indigo reaction conditions with 2-aminoanthraquinone, fusing it with caustic potash, to obtain the colorant. By 1906, Bayer had introduced the first vat red and marketed a range of colors under the Algol brand. The United States imported vats from Germany and, from 1907, Switzerland. Domestic production was hindered by German patent protection, the lack of sufficient anthracene (source of anthraquinone), inadequate technical expertise, and the large investment needed for organic solvent operations and specialized equipment.

A breakthrough occurred in 1917 when government chemists in Washington DC developed a process to manufacture anthraquinone from readily available coal-tar naphthalene and benzene. Vapour phase oxidation of naphthalene gave phthalic anhydride, which was condensed with benzene to form 2-benzoxy benzoic acid (Friedel-Crafts reaction), followed by ring closure with sulphuric acid to afford anthraquinone. Sulphonation of anthraquinone gave anthraquinone-2-sulphonic acid, named silver salt because of the silvery sheen of its crystals.
Reaction of silver salt with ammonia in an autoclave at 200 °C and pressures of up to 1000 psi yielded 2-aminoanthraquinone, a source of several vat dyes. The use of toluene instead of benzene gave 2-methylantraquinone, the starting material for vat orange dyes. Far more significant, however, was the versatile 1-aminoanthraquinone. This required mercury-catalysed sulphonation of anthraquinone, to afford what was known as diamond salt, followed by arsenic-catalyzed amination. Diamond salt was a source of olive greens, browns, greys, etc. This often involved many steps, apart from separating, drying, and finishing. Vat dye processes included the production of other intermediates, such as benzanthrones, in which an additional aromatic ring was added on to anthraquinone (Figure 8).

In 1919, Du Pont accomplished the first successful commercial production of anthraquinone vat dyes in the United States. One year later, a range of colours was available, marketed under the name Ponsol for Du Pont and Anthrene for the Newport Chemical Company. In 1927 the National Aniline & Chemical Company, a subsidiary of Allied Chemical & Dye Corporation, entered the market with Carbanthrene Blue GCD, Yellow G, and Black B pastes. In 1928 the production of vat dyes, excluding indigo, grew to 6.3 million pounds, representing almost 7 per cent of the total dye production in the USA.

Competitive pressure now compelled the General Aniline Works to supplement its imported products by entering the vat dyes market. In 1927, 157,000 lbs. of Indanthrene Brown R was made at Linden in powder and paste forms (Figure 9). In 1928 the Alizarine Department was merged into the new Vat Colors Department. The product line was expanded in 1929 with Indanthrene Olive RA, Indanthrene Dark Blue BOD Paste, and Indanthrene Brilliant Orange RKA, all replacing the imported types. The I. G. Farben designation Indanthrene would be used until the end of vat dye production at Linden in the 1970s.

Another important development was the conversion of sulphur black into a blue colorant. This was a further example of the growing capabilities of American manufacturers. In 1925 an
attempt was made to introduce an I.G. Farben process at Linden, but it was a total failure. Three years later the Linden Sulfur Color Department achieved the successful conversion, and a special Sulfur Blue Department was created to take advantage of the important new commercial product.

During 1927, I. G. Farben sent a team of technical specialists to the USA to expand and reorganise the US facilities. In June 1928 I. G. Farben consolidated the General Aniline Works, the interest of Bayer in the United States, Agfa-Ansco, Winthrop Chemical Company, and two other foreign subsidiaries, Norsk Hydro, of Oslo, and dyemaker Durand & Huguenin of Basel, into a Swiss holding company known as I. G. Chemie (Internationale Gesellschaft für Chemische Unternehmungen A. G.). The following year the American firms merged to become the American I. G. Chemical Corporation of New York. Financial control was exercised through I.G. Chemie with a unique agreement. I.G. Farben guaranteed the dividends of I. G. Chemie in return for the option to purchase I. G. Chemie’s foreign investments at book value. These manoeuvres enabled I. G. Farben to further strengthen its position in the USA, its leading market, and to raise funds in the capital market to pay for the restructuring costs. This also compensated for the fact that Sherman anti-trust legislation prevented I. G. Farben from forcing U.S. dye-makers into the cartel arrangement that was being organized with Europe firms around 1930.

By the close of 1932, I. G. Farben had invested US$12 million in modernizing and expanding its U.S. dye operations. Though the profits in 1930 were insufficient to cover variable costs due to the new investments, I. G. Farben became one of the big four dye producers in the USA. Together, I. G. Farben, DuPont, National Aniline & Chemical, and Calco Chemical (an American Cyanamid subsidiary) held a 90 per cent share of the U.S. market. I. G. Farben had now gone some way towards regaining some of the leadership position the German firms had enjoyed before World War I.

During the following years there were further transfers of technical experts from Germany, including Dr. Francis P. Bluemmel, who, with almost a decade of prior experience at Ludwigshafen, joined Linden to take charge of intermediates in 1935. Later he was appointed supervisor of process development for vat colours.

The introduction of synthetic fibres stimulated the invention of new dyes. Celliton acetate colorants, mainly based on derivatives of 1- and 1, 4-aminoanthraquinone, were introduced by I. G. Farben in 1934. Shortly after, Linden made some members of this class. Also in 1934, there appeared a completely new chemical class of colorant, the phthalocyanines, introduced by Imperial Chemical Industries (ICI) in Britain. Much to the surprise of ICI, the manufacturing process was quickly improved by I. G. Farben, which introduced its products as Heliogens. They were manufactured at Linden from 1936. Another source of know-how at General Aniline was based on licensing of Algosol (soluble vat) dye and intermediate processes from Durand & Huguenin.

Diversification: Amino Resins and Surface Active Agents at Linden

During the 1930s the American chemical industry embarked on extensive programmes of diversification, stimulated by new needs, such as the requirements of the electrical and automobile industries, and discoveries made possible through advanced research facilities that arose from dye research. Du Pont became synonymous with polymers, particularly nylon, and American Cyanamid with amino resins, notably melamine and sulfa drugs. Diversification at General Aniline was also extensive, though closely tied to innovations made at I. G. Farben, at first amino resins and surfactants.

Commencing in 1931, the Linden plant manufactured amino resins based on I. G. Farben patents and arrangements with European and American manufacturers, including American Cyanamid. Manufacture of I. G. Farben Unyte urea-formaldehyde resin was carried on through a subsidiary, Unyte Corporation. The Unyte unit was managed by Max W. Levy, who had worked on sulfur dyes at Linden in 1919, and then moved on to the first manufacture of intermediates, also in 1919. In 1936, Unyte combined with Toledo Synthetic Products to form the Plaskon Company. The products later included phenol (Bakelite type) and melamine resins. In 1948, Plaskon, that operated in the then building No. 35, was acquired by the Libby Owens Ford Glass Co., of Toledo, Ohio, and soon after resin manufacture at Linden ceased.
Detergents represented far greater potential for growth, in part because of the intense competition among amino resin producers. I. G. Farben was an early manufacturer of synthetic detergents (surface active agents, known today as surfactants). These synthetic products were soon appreciated for their far superior emulsifying, wetting and dispersing properties when compared to soap, and found many industrial and consumer applications. In 1930 the Igepon A products, fatty acid esters of hydroxyethanesulphonic acid, were first marketed in Germany. The A stood for äthan, or ethane. The Igepon T products, introduced the following year, were amides formed by reaction of fatty acids (such as oleic acid) with taurin compounds (aminoethanesulphonic acids). The General Aniline Works quickly saw the market potential for these products in the USA, obtained the basic technology from I. G. Farben, and developed manufacturing processes and applications at the Linden plant. Igepon A was produced in 1931; Igepon T followed in 1932, as a powder made in a German-built spray dryer. In 1933 Linden produced Igepon T gel in response to the textile industry’s preference for a non-dusting, easy-to-handle liquid. This product, eventually the largest selling Igepon, was not made in Germany. The surfactants business was very profitable due to patent protection and represented the most significant area of diversification for Linden. In surfactants, at least, the generic model adopted for the introduction of novel dyes in the United States, based on initial protection of knowledge, sometimes through imports, and sometimes through trusted employees, was not strictly followed.

**Linden under I. G. Farben.**

By 1937 the Linden plant was one of the larger manufacturing sites for organic chemicals in the USA. As many as 300 dyes were produced in addition to 400 intermediates, some of which were supplied to the Rensselaer plant for conversion to dyes, and the two important surfactants. The dye range consisted of both commodity and specialty colours. All manufacturing was carried out in batch operations. The largest volume commodity products were run in dedicated equipment. Smaller volume products that were run less frequently were made in flexible equipment. The multi-purpose reactors, generally located on the second floors of buildings, could withstand acid and basic conditions, and high and low temperatures and pressures. The 145-acre site had a power house; machine shop; lead burning shop; cooperage; laboratories (research, control, analytical); pilot plant; and manufacturing buildings (Figure 10).
The Linden plant was divided into three groups, or blocks, of buildings designated A, B and C, each running north to south, with the A block at the east, closest to the Arthur Kill. The buildings were arranged in ordered rows separated by roadways and railway sidings. The A block, that included the original structures dating from the World War I period, had buildings for the production of the black and dark blue sulfur colors, the warehouse, power house, and the first administration offices. All machinery was electrically driven by 220 volt current supplied by a steam-driven generator. Compressed air was supplied by central compressors in the power house. Steam was produced at both 90 psi and 450 psi and distributed throughout the site. The utilities were originally centralized in the A block that also contained the original Engineering Department, machine shops, and repair and maintenance organizations. The Engineering Department, including its various branches, was moved to newer B block building No. 46 in 1928. The B and C blocks contained modern buildings,
made of steel and brick or concrete, and fitted with large windows for light and good ventilation (Figure 11).

Figure 11. General Aniline Works, Linden, looking north, July 1947. At right is block A, with closest building No. 204, the newly constructed pilot plant, mainly for acetylene chemistry. At centre is block B, and at left is block C, with building No. 53 closest. Photograph courtesy of Newark Public Library.

Intermediates for azo dyes were produced in two buildings, Nos. 46 and 49, in the B block, each bridged to a four-storey building, No. 48, built in 1934, that on the lower floors served as a warehouse, and above them housed the control laboratory. The older building, No. 46, dating from late 1928, was used for intermediates that required a long manufacturing cycle or campaign (two to ten days) for processing. In one section there was a long row of kettles for acid reactions, such as sulphonations and nitrations at temperatures up to 150 °C. The products, transferred by compressed air to diluting kettles or tanks, were precipitated by adding salt or by neutralizing excess acid with lime. Products were then separated by filter presses or brick-lined vacuum filters. In some instances the processing was completed at this stage and the finished product discharged into barrels. In other cases the filter residue was waste material and the product was in solution (filtrate), requiring further processing. This section of the building also housed kettles designed for the reduction of nitro compounds to amino compounds. The second section of the building was used for alkaline reactions such as caustic fusions required in the manufacture of vat dyes. In this section there were batteries of several kettles grouped for reactions carried out at various pressures. The kettles discharged to brick-lined tanks. The flexibility of equipment allowed the processing of 8 to 14 different products simultaneously. One hundred different products were made in building No. 46 in 1937.

The newer intermediates building, No. 49, erected in 1937, was designed for products requiring shorter cycles and processes that required organic solvents, such as vat dye processes. It included a distillation unit for recovery of solvents. The equipment was designed and laid out so that it could be regrouped for various production schemes.

The laboratory in building No. 48 also provided space for research facilities. It was there that on 26 August 1936, Dr. Paul Nawiasky, a vat colour expert from Ludwigshafen, inaugurated a formal research department. His staff consisted of two, a Dr. Menard, who left after a short while, and Gus Luttringhaus, the first laboratory assistant. The laboratory contained eight benches, and was known as the Grasselli General Laboratory. Later members of the department included Dr. Albert Vajda (joined November 1937) and Dr. Werner Freudenberg (October 1939), later with the Intermediates Department, and Dr. Jesse L. Werner (December 1938), and Dr. John Taras (October 1939), subsequently associated with Vat Colors. In 1938,
the management named the laboratory the Research Laboratory. Its principal function was dye research. In the same year, intermediate building No. 48 was enlarged. The main structures in the C block, dedicated mainly to alizarin and vat processes, were two large buildings, Nos. 50 and 52, connected by a bridge known as building No. 51, that housed the control laboratory for processes conducted in this block. On the ground floor of the north building, No. 50, trucks delivered raw materials and received containers of finished dyes. As in the B block, the second floor housed kettles in which intermediates, some made in the B block, were converted into dyes. The dyes, usually in liquid suspension, were separated by filter presses on the third floor. The dye filter cakes were the transported across the bridge to building No. 52 where they were dried or mixed as pastes. The drying was done on the third or top floor, the grinding on the second, and the milling on the ground floor. Several types of dryers were used: vacuum shelf dryers; hot air dryers; and horizontal, cylindrical dryers fitted with revolving blades. Building No. 53, to the south, was erected in 1938, and from then served as the finishing and warehousing unit. Imported Cellitons, for example, were dispersed and standardized there.

**Rensselaer and a Merging of Interests**

The Rensselaer site was just under half the size of Linden and the arrangement of buildings was consequently far more compact. There the ordering in blocks similar to Leverkusen was also adopted during the period of expansion carried out from the mid-1920s. Production building No. 86 was erected in 1927 and extended in the following year. Building No. 62, for the bulk storage and distribution of acids and caustic soda, was completed in 1929. A new warehouse, building No. 89, was erected in 1930. Building No. 75, completed in 1932, and expanded in 1936 and 1942, housed the analytical, research and dye laboratories and offices for the works production management and accounting. Azo dye production building No. 83 dating from 1916 was enlarged in 1933 and 1935. The plant infrastructure was improved in 1933 by construction of building No. 91 that included the main gatehouse, employee locker rooms, cafeteria and hospital. This was followed in 1936 by building No. 88 that contained milling equipment for the finishing of powder dyes. These various structures represented ‘examples of purely functional industrial buildings mixed with an amalgam of Bauhausian, International Style, and Art Deco-inspired architecture.’

General Aniline now dominated the vat and azo dye markets as a result of the many patents assigned to it by I. G. Farben and the expansion of its facilities. For a while, the company was the leading producer of dyes in the United States, at least until Du Pont caught up in the late 1930s. Despite the Depression, dye manufacture in the United States during 1936 was at record levels, 54,100 metric tons, which was 4500 tons greater than in 1929, the previous record year. In 1937, Linden produced sulphur dyes, alizarin dyes, Indanthrene dyes, Heliogens, Cellitons, azo-dye intermediates, and surfactants and textile auxiliaries. Two years later there were 1220 employees at General Aniline.

The war in Europe initiated major changes in the ownership, management and direction of General Aniline. In late 1939 I. G. Farben prudently dropped the I. G. initials in the name of its American holdings, forming the General Aniline & Film Corporation. This move merged General Aniline Works with Agfa-Ansco, that marketed Agfacolor film in 1936, one year after Kodak introduced Kodachrome, and Ozalid, maker of blueprint copying machines. However, war in Europe meant, once again, shortages of supplies from Germany, including of photographic chemicals for Ansco. In the case of colour formers, derivatives of aromatic amines, not even the formulae were known.

**U. S. Government Ownership**

Even before the outbreak of war in Europe, concerns over possible Nazi influences on American industry led investigators from the Securities and Exchange Commission to raise questions about the ownership of General Aniline. Was it I. G. Chemie or I. G. Farben, and what was the connection? After they received evasive answers from three members of the board, government officials concluded that I. G. Chemie was no more than a dummy corporation for I. G. Farben. The decision was made to remove German board members. Dietrich A. Schmitz, president of the company, one of the last Germans on the board, and a brother of Herman Schmitz, chairman of I. G. Farben, was fired in October 1941 after a failed attempt to oust the American board members.
The I.G. Farben influence that began in the collaborative arrangement between Bayer and Grasselli in 1924 came to an abrupt end following American entry into World War II in December 1941. The Treasury Department immediately installed 17 secret service agents in the main offices and plants of the corporation to ensure American control of all activities and prevent disclosure of sensitive information to Germany.  

Then in a stunning move in January 1942, the Treasury Department ousted five German-born executives, all naturalized American citizens, for personifying the Nazi domination of the company. These officials were the senior operating executives of the corporation. One was Rudolph Hutz, vice president in charge of general production and a director, who had been interned in World War I. Fifty other executives and key workers, regarded as undependable, were also fired.

There followed a reprise of actions toward the Bayer Company in World War I. On 16 February 1942, the Secretary of Treasury issued an order for transfer of stock to the government, nothing less than a formal seizure of the assets of General Aniline & Film as enemy property. Four American businessmen were put in charge as appointees of the Treasury, charged with redirecting activities to the war effort: Robert E. McConnell, with a background in mining and banking, as president; and, as vice presidents, George Moffett, chairman of Corn Products Refining Co.; Robert E. Wilson, president of Pan American Petroleum & Transportation Company; and A. E. Marshall, president of Rumford Chemical Works. The first director of the dyestuff division was Colonel Joseph H. Bates, of the Bates Chemical Co., Inc., of Lansdowne, Pennsylvania, who served from March 1942 until the end of 1943. Reorganisation in July 1943, after Leo T. Crowley replaced James E. Markham as Alien Property Custodian, led to the appointment of George W. Burpee as president. Evan C. Williams, formerly at the Shell research laboratory in California, was named vice president and director of research.

Following Americanization, General Aniline & Film Corporation supplied 50 per cent of the federal requirements for vat dyes used in military uniforms, and was the largest producer of this dye class in the United States. Head of vat dyes at Linden after the government took over was Russell Baker, a 1916 graduate of Lehigh University who joined Grasselli in 1920 to take charge of the alizarin section. At the end of the 1940s he became general manager of the plant. Ernest K. Halbach, then president of GDC, served on the Industry Advisory Committee of the War Production Board that helped the government secure chemicals, including dyes, for war production. General Aniline had a distinguished war record, with both Linden and Rensselaer plants receiving the Army-Navy E production award for outstanding production of dyes for uniforms, camouflage cloth and smoke bombs; synthetic detergents; waterproofing compounds for tents; mildew preventatives; and chemical intermediates. Almost 15 million lbs. of dyes were produced in 1943 for military purposes alone, some 6 million pounds more than in the previous year. Corporate sales rose from US$40 million in 1941 to almost US$60 million in 1943 due to the record production of dyes, synthetic detergents and photographic products, aided no doubt by the influence of Halbach in procuring orders via GDC.

An important strategic asset, including in the military sense, that came into the hands of the Americans arose from a 1940 agreement over patents between General Aniline & Film and I. G. Farben, whereby General Aniline became owner of certain key German innovations. The agreement covered research, inventions and technical knowledge and experience. Included were details of novel high-pressure reactions of acetylene, some of which had been investigated at Linden from 1937, including vinylation, the reaction between acetylene and alcohols to form vinyl ethers. A new pilot plant, building No. 201, had been erected for this type of work in 1940. In 1941 building No. 201 was taken over by Dr. Hans Beller, a former Ludwigshafen chemical engineer, whose main challenge was development of a completely different product, namely carbonyl iron, based on both patents and know-how previously acquired from I. G. Farben. Beller’s endeavours enabled the Linden plant to produce carbonyl iron powder, used to manufacture radio frequency electrical cores needed by the military. In the first step, iron pentacarbonyl was produced by a high-pressure reaction between iron and carbon monoxide. This intermediate was then decomposed by heat to form chemically pure iron. The resultant powder consisted of very fine spherical particles with superior electromagnetic properties. The product was so critical to the military that a standby plant was built at the Huntsville Arsenal, Alabama, following failure of the competing Ferroline Corporation process at Shreveport, Louisiana. General Aniline was retained to design the plant and start it up in July 1943. After 125,000 lbs. of strategic inventory was produced, the Huntsville plant was mothballed until 1949 when it was restarted and leased by General Aniline. Linden production was then transferred to Huntsville.
More Wartime Research and Development

Prior to 1942, General Aniline & Film depended on I. G. Farben for research to support all of its business areas. Though General Aniline had not duplicated I. G. Farben research in the United States, details of a few innovations made at Linden were sent to Germany. These related mainly to dyestuffs. A small amount of research was carried on in the photographic film plants. Certainly, no fundamental research or expansion into new fields was done. ‘The result of this policy was the complete subservience of the Company [General Aniline] to its German associate, for the results of the German research were never disclosed to the Company.’ Moreover, ‘in many cases important material was only communicated verbally to the most trusted employees of the Company on the occasion of their visits to Germany…. The information thus obtained was not disclosed to other employees of the Company. Thus on several occasions when the man in possession of information died [General Aniline] was obliged to send another employee to Germany for instruction in the particular process.’

The outcome was that after the government takeover, General Aniline had 3900 patents in its vault but lacked the technical staff to commercialize the inventions. In one of the most forward-looking initiatives of the American management team, US$10 million was committed to create a first-class research organization. A Central Research Laboratory was established in the Lehigh Valley, at Easton, Pennsylvania, in the summer 1942. The location was chosen because a five-storey building, leased from the Stewart Silk Corporation, was available, and could be immediately occupied. This was an important consideration at a time when there was a shortage of construction materials. The building, with 70,000 square feet of space available, was quickly remodeled for laboratory service. By the autumn of 1942, an initial staff of 50 chemists, engineers, physicists and technicians had been brought together by Dr. William D. Hanford, the research manager. The research staff came from both the corporation and leading scientific institutions in the USA. The staff was soon increased to 400 employees, making the laboratory one of the largest industrial research centers in the USA. The early effort was focused on dye chemistry but was soon extended into broader fields, including high-pressure acetylene chemistry.

The Easton laboratory was some distance from the General Aniline dye plants: 65 miles from Linden and 195 miles from Rensselaer. Under normal circumstances, at least around 1940, a company’s research facility would be located closer to a production site to allow field visits, conduct pilot tests and promote the exchange of information. However, war with Germany was underway and the government was anxious to move quickly to protect and develop the technology of the seized company. The latter may also have been factored into the decision to site the research laboratory in a rather remote location. Treasury Department agents closely monitored the activities and communications of the research staff. German chemists, including even senior managers believed to have close ties with their homeland, though not high security risks, were reassigned to the Easton laboratory. One such chemist was Dr Harry Grimmel, who had worked for Bayer at Leverkusen and came to Rensselaer in 1926 as general manager. He was appointed research section head in azo dyes at Easton. After his forced transfer to Easton was over, Grimmel (Figure 12) left the company in 1947 and founded Metro Dyestuffs in Coventry, Rhode Island, later incorporated into Hoechst Chemical Corporation.
Dr Ferdinand Max, senior manager of General Aniline Works, was similarly reassigned to Easton in 1942 as director of vat dyes research. Max left the company in 1948 to join competitor Ciba States Limited that was planning to manufacture vat dyes at Toms River, in Ocean County, New Jersey. Another German chemist assigned to Easton was Dr F. Reichel whose fiancée lived in Germany. When Allied bombing of German cities began, Reichel complained to his neighbours, who called in the FBI. Reichel was handcuffed in the Easton laboratory, carted off to Ellis Island, and later to a special prison. One Linden research chemists recalls how the FBI removed a few staunch Nazis from the facility, while a Rensselaer chemist remembers a German colleague who was followed by a Treasury Department agent everywhere, even to smoke breaks outside the laboratory.

At Linden, H. P. Angermueller, Mr. Kropp, and other engineers, as well as chemists, originally from BASF at Ludwigshafen, were dismissed. Angermueller was replaced by David E. Pierce, who in 1945 was appointed chief engineer for Linden, Rensselaer, and Easton. The pre-war works manager Paul Strubin remained at Linden, probably because he was of Swiss origin. The only German chemists allowed to remain at Linden were the few who were Jewish, were married to Jewish women, or who had expressed strong anti-Nazi sentiments. They included Beller, who was moved to Linden in 1941. Some former I. G. Farben Jewish employees had been assigned to posts outside of Germany, including at Agfa-Ansco, by sympathetic managers at certain divisions.71

In 1942, the Linden research laboratory became known as the Grasselli Research Laboratory, to distinguish it from the Easton facility. From August 1942, the Grasselli laboratory included an Ansco division that undertook research into photographic materials. The constitutions of the important colour formers were quickly worked out with the aid of chemists at Easton. The outcome was production from 1942 of colour formers in what was known as department 600, erected on the roof of building No. 48. In 1943, after 15 chemists were transferred to Easton and four to manufacturing departments, the Grasselli Research Laboratory became the Process Development Department of what was now the General Aniline Works Division.

By 1945, the Easton Central Research Laboratory employed 107 research workers, of whom 67 had PhDs or higher degrees. The staff included several physicists. In addition, research and process development was carried out elsewhere by specialists that included 68 men with degrees in engineering and science. Research expenses had climbed from US$382,000 in 1941(of which US$13,000 was spent on basic research) to US$2,445,000 in 1944 (US$1,582,000 on basic research). The General Aniline Works Division now manufactured dyestuffs and auxiliaries used in the dyeing processes, miscellaneous chemical products including detergents, carbonyl iron powder, and resins; the Ansco Division manufactured photographic films, papers and chemicals, as well as cameras; and the Ozalid Division produced sensitized materials and machines for printing and developing.
Easton pioneered automated methods for standardizing dyes with respect to shade, strength and brightness. Dr. Isaac H. Godlove was senior physicist at the Easton laboratory, which he joined in 1943 after working for the Munsell Color Company and Du Pont. The colour research of Godlove and his colleagues Harry Hemmindinger and Hugh R. Davidson led to the development of the General Aniline Librascope in 1949. This instrument combined a General Electric recording spectrophotometer with an automatic tristimulus integrator. The Librascope represented breakthrough technology that enabled colour measurement and analysis in only a few minutes with a high degree of precision. The instrument would find practical applications in dye plants and textile mills where it resulted in objectivity in colour testing.72 Godlove published many technical articles and was recognized as a leader in the field of colour and its application to human psychology.

The Early Post War Period

During 1944 and 1945 production of dyestuffs at General Aniline was at record levels, and in the latter year was twice that achieved in 1941. The Linden plant was producing 800 different dyes and 700 intermediates. Edwin Meier, the Swiss chemist who joined Grasselli in 1918, was head of the Sulfur Colors Department that also made surface-active chemicals. There were around 65 sulfur colours, and an equal number of surface active and auxiliary chemicals employed in the textile industry. Novel surface active products and allied detergents were bringing in greater profits than sulfur colours. New products included Nekal NS, a wetting agent for textile treatment, and Glim, a liquid for quick, easy dishwashing, developed during the war and introduced in 1946. Products manufactured for Ansco in Department 600, on the fifth floor of building No. 48, included 6 colour formers, and 14 sensitizing dyes.

The two dye-making plants employed almost 4000 people and produced 75 million pounds of dyes and intermediates per year. Rensselaer was turning out 1200 different dyes and 1000 dye intermediates.73 The product line covered almost every type of dye for the textile, paper, and leather industries: azos, aligosols, alizarins, azosols, cellitons/cellitazols, Heliogens, Indanthrene and other vats, lake colors, naphthols, nigrosines, palatines, rapidogens, sudans, and triphenylmethanes. In 1945, president George W. Burpee announced that there was ample dye production capacity to meet the needs of the textile industry. However, by the beginning of 1946, when monthly production of chemicals at Grasselli was 5,000,000 lbs., there was a large unfilled export demand for dyes.

The monthly research letters provide a useful glimpse of activities at Easton. Most work focused on exploiting the patent position held as a result of the 1940 agreement. ‘These patents deal, to a very large extent, with the chemistry of acetylene and for new methods of handling acetylene under pressure and at high temperatures. Under these patents,’ it was recorded in December 1945, ‘two products have been developed through the pilot plant stage: 1) Polectron, or polyvinyl carbazole; and 2) Koresin, or the reaction product of p-tert.butylphenol with acetylene. Both of these products require the same general technique for handling acetylene under pressure.’74 The process of greatest utility was based on the reaction of acetylene with alcohols to form vinyl ethers. Research had been hampered under the wartime conditions, but had subsequently been placed on a systematic footing, particularly the polymerization involving methyl vinyl ether, and other ethers. Studies into the role of peroxides as initiators in vinyl polymerization were also conducted, and, as a result, the first polymerisations of vinyl pyrrolidone, obtained in five steps from acetylene, were carried out using hydrogen peroxide at 100 ºC. Information from Europe ‘on new method for synthesis of acrylic acid esters … fits nicely with our work on the development of acetylene chemistry.’ There was an interest in novel vat dyes and dyes for nylon. More physicists had joined the staff at Easton, ‘which enables fundamental research on properties of dyes, detergents, polymers.’75 On 1 October 1946, Hanford was replaced by Dr Arthur L. Fox, who had joined Easton in 1942 from Du Pont to take on applications research. Assistant director of research was Warren F. Busse, previously section leader in physics at Easton.

The Grasselli laboratory, or Process Development Department, at Linden had a staff of 130, including 26 chemists and engineers, and consisted of five sections: Vat Colors; Intermediates; Ansco; Process Engineering; and Analytical. One of the most ambitious and capable chemists in the department was Jesse L. Werner, who joined General Aniline as a research chemist after receiving his PhD from Columbia University in 1938, was group leader in the Vat Colors Section during 1942-46, and then section leader of the Intermediates Section. He also served as technical librarian, and would later head General Aniline. In May 1946, Hans Heer, who had undertaken research into alizarin dyes during the 1920s was
appointed head of the Vat Color Department. Nawiasky and colleagues developed wetting agents and Heliogen blue in the Process Development Department.

To meet the tremendous growth in manufacturing operations an increased water supply was essential at Linden, particularly for cooling purposes. By 1945, the Du Pont supply was sufficient to satisfy only its requirements. General Aniline decided to draw directly from the waters of the Arthur Kill, that had one-third the salinity of sea water. A new pumping station was erected on bedrock below the Arthur Kill during 1945-46. The intake was located at a depth of 24 feet below average tide level and the low temperature provided good cooling efficiency. The flow ranged from an average of 5000 gallons/minute to 9000 gallons/minute in the summer. A disadvantage of using this water source was the high concentration of chloride and dissolved solids. However, corrosion was less of a problem than buildup of scale in cooling equipment. As a result, the cooling equipment had to be oversized and mechanically cleaned of scale about every two years. The use of once-through cooling water had another advantage for the Linden plant, but it came at the expense of the environment. The wastewater effluents from production were combined with the spent cooling water in a common sewer and returned to the Arthur Kill without any treatment.

Some renumbering of the Linden buildings had taken place in 1946. Those engaged in dye and allied organic chemical production were designated numbers 1 to 99, administration buildings were numbered 100 to 199, and buildings that manufactured products other than dyes were numbered from 200 on. Two letters followed the numerals. The A, B, and C blocks, from south to north determined the first letter. Then the entire tract of buildings was divided into sections running from west to east, which determined the second letter.

Reppe Acetylene Chemistry in America

In May 1946, president Burpee announced that work had commenced on a new US$1,250,000 building at Linden that would serve as a semi-works and pilot plant for the manufacture of chemicals from acetylene under conditions of high pressure. This was the first unit of its kind in the United States. It followed investigations carried out at Linden since 1937, and followed up at Easton from 1942. Experimental quantities of vinyl ethers had already been produced and were made available to chemical manufacturers. The new two-storey building, according to the numbering scheme, was No. 204 (or 204AA, with the two letters added), located on a vacant area at the south of the A block (Figure 11). Some 640 piles supported the foundations. One of the two wings was made available to the Process Development Department and the other to the New Products Development Department. The building incorporated a reinforced explosion-proof stall for high-pressure acetylene experiments. The acetylene was produced from calcium carbide in a nearby building, since natural gas was then considered too expensive as a source.

Acetylene-derived chemicals represented a major technology breakthrough for General Aniline and became an outstanding commercial success. The basic research for safely reacting the highly flammable gas with other chemicals at high pressures was done by J. Walter Reppe at I. G. Farben from the late 1920s. The research work was highly dangerous, though eventually highly successful, even if commercialisation was restricted. In England, ICI had undertaken similar work in the 1930s, but did not advance beyond a small-scale process, in part because of the danger. General Aniline acquired the Reppe acetylene inventions in the last batch of 850 patents received from I. G. Farben in 1940. The Easton laboratory developed syntheses for thirty products that showed potential commercial applications (Figure 13).
The starting point for many of these products was the reaction of acetylene under pressure with formaldehyde to form butynediol. This was reduced to butenediol and then to the saturated butanediol. These alcohols are precursors to esters, carbamates, polyesters and urethanes. The lower alkyl pyrrolidones are excellent as polymer solvents, paint strippers and industrial cleaners. During World War II, Linden produced small quantities of two acetylene products for the military, as already mentioned, Polectron and Koresin. Polectron was poly(vinyl carbazole), also made in Germany as Luvican. The Grasselli product was useful in electronics, for insulation, and where high operating temperatures were employed. It was similar to styrene but had improved heat resistance; mass polymerization gave almost clear glasslike castings. However, for peacetime use it suffered from high cost, lack of uniformity, poor colour and poor mechanical properties. The carbazole came from coal tar or diphenylene imine. Copolymers of vinyl carbazole and styrene were found to have good moulding properties. Koresin, also first developed in Germany, was a condensation product of acetylene and \( p \)-\( \text{tert} \)-butyl phenol, and was a very effective tackifier for GR-S synthetic rubber.\(^{81}\)

The most important product arising out of the acetylene work at Grasselli was vinyl pyrrolidone, originally discovered by Reppe at Ludwigshafen (Figure 14). This involved dehydrogenation of butanediol to yield butyrolactone, which was condensed with ammonia to afford 2-pyrrolidone (butyrolactam), followed by vinylation with acetylene, again under pressure, to afford \( N \)-vinyl pyrrolidone. The latter was the monomer for polyvinyl pyrrolidone, a white powder, soluble in both alcohol and water, that served as a valuable blood plasma extender, made first in Germany during World War II, and during the early 1950s at Linden. At that time its main use was as a blood substitute. It formed transparent films on glass, plastics and metals, and found application in the formulation of cosmetics, particularly hair sprays. The polymer, known as Polyclar, was manufactured at Linden until the 1980s, and the copolymer with an aminoalkyl methacrylate, Gafquat 755, until 1991.
The marketing of vinyl derivatives and polymers was taken over in 1952 by Jesse Werner, when he was appointed director of commercial development (a post he held until 1959, when he was appointed vice president of the corporation). A favourable response from the marketplace resulted in the decision to build a US$6 million acetylene chemicals plant in Calvert City, Kentucky, that came on stream in 1956. Linden’s Hans Beller (Figure 15), who had earlier cooperated with Easton in acetylene products research, was project director during the construction phase, and was appointed the first plant manager.

The acetylene chemicals technology was difficult and there were two serious explosions at Calvert City in the early years. However, General Aniline succeeded and was the only producer in the United States, at least until the Dow-BASF process was introduced in 1958. The Calvert City plant lost money until 1962, when the business became highly profitable, with gross profit margins in excess of 50 per cent on production costs beyond the breakeven volume. A second acetylene chemicals unit was built in Texas City, Texas, in 1968 to fill the demand for the many new applications of the products. The acetylene was produced from petrochemical fractions. Elsewhere acetylene-based syntheses had been replaced mainly by those based on ethylene, also used in the production of an important Linden product, ethylene oxide.
Detergents and Surfactants

Another outcome of wartime work was the consumer-oriented liquid detergent called Glim, made at Linden and marketed from 1946, though the company lacked the sales expertise and cash to enable growth of this product. Also, manufacture depended upon a process for manufacture of ingredients covered by a patent held by Rohm & Haas. In 1948 General Aniline sold rights to B. T. Babbitt, Inc., and from then on made the detergent base for the wholesale market.

A more important development at Linden in the 1940s was the production of Igepal non-ionic surfactants by the reaction of alkyl phenols with ethylene oxide. During 1950-51, surfactant production was undertaken on a large scale at both Linden and Rensselaer as part of a US$2 million project. In 1956, General Aniline drew up plans to produce at Linden on a larger scale the Igepals and the sulphated anionic derivatives called Alipals. This included manufacture of the key raw chemicals, ethylene oxide and alkyl phenols. A US$8 million surfactants plant was constructed in 1957, including an ethylene oxide unit, located at the western end of the site, and rated at 60 million pounds per year capacity (Figure 16). It was also equipped to manufacture ethylene glycol for the anti-freeze and fibre markets as well as diethylene glycol. The ethylene was delivered by pipeline from the nearby Bayway Refinery of Esso Standard Oil. A second surfactant unit was built the same year on part of the 55-acre Calvert City plant site.

Ethylene oxide products now covered Igepal, Emulphor, Peregal, and Diazapan textile auxiliaries that included emulsifiers and a range of dispersing, wetting and cleaning agents.

Figure 16. GAF Linden, seen from the west, mid-1960s, with ethylene oxide unit in foreground and warehouse building No. 120 beyond, at center. Edelstein Collection. Photographer unknown.

Decline in Business

Corporate sales had reached a peak of US$73 million in 1944 with a net operating profit of US$3.5 million after taxes. During 1945-46, however, and despite growing demand for and output of chemicals, the corporate financial performance declined and there were indications of serious problems within the company. The General Aniline Works Division sales were 50 to 55 per cent of the corporate total but contributed 80 to 90 per cent of the total profit. In 1946 corporate sales slipped to US$63.5 million with net operating profit of US$2.7 million. It was only the elimination of excess profits taxes that saved the company from a disastrous financial performance. The profit shortfall was even more obvious when compared to General Aniline’s three major competitors, whose 1946 profits increased 40 to 45 per cent in one of the best years ever for American industry. It is instructive to consider how this situation arose, particularly as a result of the changes in ownership.

One major problem was that the control of General Aniline by I.G. Farben during the 1928-41 period created inherent weaknesses. Things worked well when the parent company supplied a steady stream of patents, new products, intermediates, manufacturing processes, machinery, and executive and technical staff. When in 1942 this link was broken, General Aniline struggled to become an independent company. Setting up an effective research organization and hiring capable American managers to run the plants was a slow process due...
to the manpower shortage during World War II. In terms of production capabilities, the company lacked the raw material integration of its competitors and had to purchase large volume starting materials such as aniline, beta-naphthol, and anthraquinone from them. In some respects, and despite its capabilities in high-pressure processes, I. G. Farben’s strength was in small batch processing of specialty chemicals and not in production engineering. By the mid-1940s the General Aniline plants were relatively inefficient and did not measure up to the best American chemical industry practices. A glaring example of lack of action was in handling of wastewater, where the Linden plant discharged untreated effluent to the Arthur Kill. General Aniline’s competitor, the Calco Chemical Company (American Cyanamid) of Bound Brook, New Jersey, had invested US$0.5 million in a multi-stage wastewater treatment plant in 1940 to meet state standards.  

Another legacy of I. G. Farben that burdened General Aniline’s costs was GDC, its exclusive selling agent whose stock was also seized by the government. GDC had a perpetual contract to sell all dyes and chemicals, charging General Aniline a 15 per cent commission. General Aniline had to carry the expensive finished goods inventory on its own books. The sales commissions cost it US$6.0 million in 1946. GDC operated out of an expensive nine-story headquarters/warehouse building that it had erected in Manhattan before the war. It scheduled plant production and totally controlled customer relations, disconnecting plant personnel from important feedback concerning the quality and performance of their products. This separation also meant that when General Aniline sold its products directly to users, it could not use the trademark names of GDC. The outcome was Antara Products, from 1951 known as Anatara Chemicals. The government purchased GDC stock from the shareholders, mainly Halbach, in 1945, and in 1953 the Justice Department merged the company into General Aniline and Film Corporation. By that time the acronym GAF was in general use, including on railroad tank cars that shipped vinyl pyrrolidone to distant customers.

The second major ownership problem facing General Aniline was continued government control. Plans to privatise the company were stalled when Interhandel, the Swiss successor to I. G. Chemie, sued the U.S. government in 1948 to recover the stock. Interhandel claimed the dividend/option agreement with I. G. Farben had been cancelled in 1940 and that the United States had illegally seized the assets of an independent firm headquartered in a neutral country. The case would be argued in the United States and international courts for years. During government ownership, General Aniline could not raise capital through a stock issue or use company stock for a merger to grow and diversify its businesses. In 1947, while General Aniline secured a US$15.5 million insurance company loan for capital expansion, its major competitors Du Pont and American Cyanamid raised US$125 million for their expansion plans.

Government ownership also resulted in a weak top management. The president and directors positions were often filled according to political patronage and turnover was extremely high. During the 1939-47 period 52 men served in directorship positions. Many of the top executives selected lacked chemical industry experience. Some had other businesses and worked only part time. Between 1942 and 1952, some 82 executives departed. The focus was on short term operational performance; strategic planning to assure the long term success of General Aniline had a lower priority. Decision making was paralyzed by executives who feared the loss of their jobs if, and whenever, the government sold the company. As a result there was very little of the sort of risk-taking that would probably have enabled the company to grow at the same rate as its competitors. A good example of the lack of confidence happened after a chemist at Easton, V. Tulagin, invented a new dye system for colour photography. His boss, Dr. Carl Barnes, viewed the discovery as superior to the Kodak system. Barnes presented the details to the company president but it was rejected, since management could not believe that a chemist in the Easton laboratory could top Kodak. Barnes quit General Aniline and would later become vice president of research at Food Machinery & Chemical Company (FMC Corporation). Many other promising young scientists hired in the early 1940s resigned a few years later when it became obvious that their inventions would not be commercialized.

Revival: A Chemicals Strategy

The period of decline, in part created by factors outlined in the foregoing, came to an end with the appointment of dynamic new management figures. First was Jack Frye, who in 1947, as president of Transcontinental and Western Air (later TWA), had been fired by Howard Hughes. Frye used his political connections to land the top job at General Aniline, chairman
Burpee was re-elected president at that time, when General Aniline employed 9500 people, including at the Ansco and Ozalid divisions. Although Frye had no chemical industry experience, he proved to be a very capable executive during his eight-year tenure. Sales and profits rebounded to record highs in 1948. A year later, Frye brought in John C. Franklin, also previously at Transcontinental and Western, as vice president. They both left General Aniline in 1955.

Demand for dyes was still growing. The Linden plant operated 24 hours a day, seven days a week, with three shifts each day. In May 1949, it employed 2365 people, and was the largest producer of vat dyes in the USA, which was now the main dye-manufacturing country in the world, and would remain so until 1970. General Aniline Indanthrenes outside the United States were marketed under the trade name Fenanthren. In 1947 intermediates building No. 49 produced 6 million pounds of intermediates and dyestuffs, half the output destined for the vat buildings in block C. Indanthrene brown 2RA, for example, was made completely in building No. 49, requiring 25 separate operations carried on over two weeks, after which the product was taken to building No. 53 for preparation as a dye paste.

Frye, however, saw the main growth opportunities in chemicals other than dyes, where the integration advantages of Du Pont, National Aniline (Allied Chemical and Dye Corporation), and American Cyanamid, all manufacturers of primary intermediates, could not be overcome.

Increased focus of Rensselaer on chemicals production began in 1950 when building No. 87 was set up exclusively for the manufacture of intermediates. A few years later, Rensselaer pioneered the manufacture of optical brighteners, as invented at I. G. Farben before the war, under the Blancophor trademark for the textile industry. Optical brighteners absorb ultraviolet light and reemit radiation in the visible blue region of the spectrum, giving textiles a whiter appearance. Several ultraviolet absorbers were also produced under the trademark Uvinul. These products, mainly benzophenone derivatives, protect plastics and coatings from deterioration by light.

In keeping with the new strategy on chemicals, General Aniline obtained a US$20 million insurance company loan in 1951 to fund capital expansion projects in acetylene chemicals, surfactants (Figure 17), and their intermediates, and the installation at Linden of electrochemical mercury cells for production of chlorine and caustic soda.
IGEPONS are the ideal scouring, wetting-out, penetrating and level dyeing agents for all fibers and fabrics.

IGEPONS are stable in acid and alkaline solutions—have excellent detergent properties—rinse rapidly—disperse lime soap and are equally effective in hard or soft water at any temperature.

IGEPONS have high efficiency in low concentrations and save time and labor.

Our nearest office will be glad to furnish samples and technical information. Your inquiries will receive careful and prompt attention.

OTHER GDC PRODUCTS:

IGEPONS — non-ionic detergents
NERALS — wetting agents
SOFOMINES — softening agents
BLANCHODERS — optical brighteners
NITALTONS — organic sequestering agents
COLORESHINES — thickening agents
EULANS — mothproofing agents
RUHLIFORS — emulsifiers
PREVENTOLS — fungicides

Figure 17. General Dyestuff Corporation Advertisement for Igepon surfactants, manufactured at the Linden, New Jersey plant. American Dyestuff Reporter, May 1, 1950.

General Aniline had significant requirements for chlorine and caustic soda for the manufacture of dyes, intermediates and chemicals at Linden and Rensselaer, in addition to a
strong merchant market for these chemicals in the northeast. A US$5 million unit came on stream in 1955 at Linden with a capacity of 50 tons of liquefied chlorine per day. The unit also produced high purity caustic soda in 50 per cent solution and flake form; caustic potash in solution and flake form; hydrochloric acid; and sodium hypochlorite. The operation was very profitable and there were plans to increase the daily chlorine capacity to 235 tons by 1963. This was based on new BASF technology that was untested, at least in the USA. It took until the end of the decade before the new unit came on stream, following extensive work by the Krebs firm of Paris, France.

In 1955, General Aniline moved the director of the Central Research Laboratory, Dr. Joseph W. Lang, to Linden. The purpose was to improve communication with the plants and the marketing office in New York during a period of rapid expansion. Dye research was transferred from Easton to Linden and Rensselaer depending on the products involved. Lang remained director of the Easton laboratory, where research in the fields of acetylene chemistry, surfactants and analytical methods continued. The research functions for the Ansco and Ozalid divisions had been moved to their respective plant sites in Binghamton and Johnson City, New York, several years earlier.

In the late 1950s-early 1960s period, General Aniline increased its activity in the pigments market. The company acquired the Collway Colors plant and research laboratory in Paterson, New Jersey, in a cash transaction. Collway Colors was a producer of azo and phthalocyanine pigments for printing inks, paint and lacquers. The growth of the pigments business led to the construction of a new unit for phthalocyanine manufacture at Linden in 1966. The main products were restricted to Heliojen blue and, by chlorination, green, despite earlier attempts at Easton to extend the colour range.

At the close of 1964, General Aniline had about 550 employees engaged in research and development of whom over 200 were chemists, physicists, and engineers holding 'more than one college degree.' Total personnel exceeded 19,000, many engaged in international operations in over 100 countries. For sake of comparison, American Cyanamid a few years earlier employed 28,200 people, 2000 outside the United States.

**General Aniline is Privatized**

Government ownership probably made it easy for private firms to poach General Aniline staff with promises of more lucrative financial packages. Phillip Kronowitt, who in 1947 had represented General Aniline on one of the last Field Intelligence Agency, Technical (FIAT) investigations of German dyestuff manufacturing, and some other Linden chemical engineers and chemists, along with Ferdinand Max of Easton, left to join Ciba at Toms River at the end of the 1940s. In 1952 they were joined, as head of research and development, by organic chemist Philip Wehner, who had worked at Easton during 1942-45, and then at the University of Chicago, under an arrangement with the Atomic Energy Commission. In 1968 he was appointed president of Toms River Chemical Corporation. In 1953, 13 General Aniline employees, unhappy with the political appointees, including those from airlines and the entertainment world, left to join Ernest Halbach at Verona Chemical Company (recently purchased from General Aniline, following its earlier ownership by GDC) and establish Verona Dyestuffs, a Division of Verona Chemical. General Aniline filed a lawsuit against Halbach, claiming US$6.2 million in damages for use of confidential information and trade secrets acquired by former employees. The lawsuit was discontinued in 1954.

After a two-decade legal battle (Figure 18) over the ownership of General Aniline, the Justice Department finally reached an agreement with Interhandel, the Swiss holding company, in March 1963. The agreement would give a 62 per cent share of the company’s value to the government and a 38 per cent share to Interhandel. The government therefore gave some credence to the claim that the ties to I. G. Farben were severed in 1940. The stock was sold to the public in 1965 for US$328 million with Interhandel receiving $122 million. The government’s proceeds went into the war claims fund, used to pay claims to American citizens for injuries and property damage suffered at the hands of enemies during World War II.
The financial performance in 1965 set a record, with sales of US$215.5 million (a 12.1 per cent increase over 1964) and net income of US$13.2 million (a 23.1 per cent increase over 1964). All four product lines, dyes, chemicals, photo, and reprographic products, showed good improvement. In 1964, Werner had split General Aniline into two divisions, one covering dyes and the other non-dye chemicals. The dye range of over one thousand individual dyes generated the highest ever levels of sales. New dyes were added for nylon, acrylic, and polyester synthetic fibers. The corporate slogan was ‘From Research to Reality,’ accompanying advertisements for novel dyes such as Genacron for Dacron polyester, and Genacryl for Acrilan. The dye units operated at full capacity and additional manufacturing and finishing equipment was installed at Linden and Rensselaer. The surfactant line, consisting of a dozen chemical types and four hundred products, was expanding at both Linden and Calvert City, and the company became one of the largest producers in the United States. New formaldehyde and methylamine units were built at Calvert City to support the growing acetylene chemicals business.97

A Personal Impression

In 1966 one of the authors (RB) had a summer job at the Linden plant as a control chemist in the Vat Color Department. It was a wonderful learning experience from the first day, with Dr. John Taras, department head, demonstrating the dyeing of cotton with Indanthrene blue. The sprawling plant manufactured a huge range of dyes, intermediates and chemicals. A young chemist could see in practice virtually every type of chemical reaction: nitration, reduction, sulphonation, halogenation, caustic fusion, alkylation, ring closure, etc. Both commodity and specialty chemicals were being produced with modern continuous processes and classical batch operations. The easy access to research chemists with years of experience, engineers
and a well stocked reference library was very helpful in troubleshooting quality and yield problems in the manufacturing units.

At this time, however, I saw that fundamental changes in the dye business were already underway. Intermediates from Europe could be imported at lower cost than manufacture at Linden, resulting in some capacity being shutdown. The company recognized that its surplus batch equipment, coupled with its vast know-how of organic synthesis, could be used for the contract manufacture of high value specialty chemicals. An agreement had been made in 1962 with Amchem Products, an agricultural chemicals company in Ambler, Pennsylvania, to manufacture Amiben (3-amino-2, 5-dichlorobenzoic acid), a pre-emergent herbicide used to control weeds in soybean cultivation. In 1966 I observed its production in a surplus pilot plant and was informed the business was very profitable for General Aniline. Amiben was a skin irritant and some chemical operators developed serious body rashes working in the unit. Area ventilation was improved and increased personal protective equipment was used. A long-term supply agreement was later signed with what had become Rorer-Amchem and General Aniline built an Amiben unit at its new Texas City, Texas, plant in 1968. Amchem purchased the unit for US$12 million in 1970 and gave General Aniline a long-term contract to operate it. The net gain for General Aniline was $2.4 million.

As mentioned earlier, the high-pressure acetylene business underwent considerable expansion, but no longer at Linden. In 1968, Calvert City introduced new production units for vinyl ether copolymers and their derivatives, enabling increased sales of the GAF Gantrez copolymers used in detergents. These products were also made at Linden. In 1969 a multi-million dollar expansion program began at Texas City, completed in 1971. The products included propargyl alcohol, 1,4-butylenediol, and 1,4-butanediol. There was also growth in production of Polyclar, a polymer of vinyl pyrrolidone then made at Calvert City. Tetrahydrofuran, or THF, made from butanediol, was produced at Texas City and refined for the northeast market at Linden. GAF, now the world leader in acetylene chemistry and since privatization free to trade with successors to I. G. Farben, in 1975 set up a joint venture with Chemische Werke Hüls AG at Marl, in the Ruhr district of West Germany, to manufacture butanediol and THF. In the USA, ISP Corporation, successor to GAF, continued to produce butanediol until 2000.

Safety and Labour Relations

In July 1966 a chemical operator at Linden was killed by exposure to hydrogen sulfide. The toxic gas was released into a three-storey dye building when a sewer line ruptured. This was just one of many serious accidents in the history of the Linden plant. In 1958 two employees were killed on the same day in separate accidents; a painter died in a fall and a chemical operator was killed by toxic fumes. In 1964, three employees working in the surfactants unit were killed by an explosion. In 1968 seven employees were injured by an explosion and fire. A worker was killed in 1979 when a blast occurred in building No. 46 which contained high pressure kettles. An operator at the Rensselaer plant was killed in 1956 when a chemical measuring tank exploded.

Although the General Aniline dye plants did experience periods of good safety performance, with no lost workday injuries for two million man hours or more (for which in 1964 the corporation received the Lamont du Pont Safety Award of the Manufacturing Chemists' Association), their overall safety performance was inferior to Du Pont. Du Pont set the standard for safety in the chemical industry with a systematic methodology to manage it. There was a strong commitment from workers and managers in the belief that all injuries were preventable. The General Aniline safety programme was more reactive than proactive. The Linden plant had an excellent medical facility with a doctor and nurse on duty and even an ambulance to rush injured workers to hospital. But insufficient effort was made in raising the level of process engineering and safety protection to the best practices of the chemical industry at the time.

After the war, General Aniline began to experience difficult relations with its labour unions. In 1946 the Rensselaer plant was shutdown for several days when 800 production workers walked out. The employees, members of the International Chemical Workers Union, protested a company appointment they believed violated the labour contract. A strike at Rensselaer in 1949 was settled when workers accepted a 3.6 per cent pay increase, bringing their average wage to US$1.73 per hour. At the Linden plant in the same year, employee morale was lowered by plant manager Russell Baker's announcement of a layoff of 300 production and other employees due to slow sales. The plant employed 2365 at the time.
Tensions increased further in 1950 when Linden plant management fired a worker who gave a false excuse for taking a day off. During a televised baseball game on that day, the worker was seen sitting in the stands by a manager watching television. The General Aniline Employees Organization, an independent union, ordered its 2400 members to walkout in protest at the firing. The dispute was settled a few days later. Workers at both plants struck frequently throughout the history of General Aniline to obtain higher pay, improved benefits and better working conditions.

**GAF Exits the Colorants Business**

The strategic direction of General Aniline took a significant turn in 1967, when the Ruberoid Company was acquired for about US$113 million. This major entry into the building materials market signaled a lower priority for the dyes business. The company further distanced itself from its heritage by changing its name from General Aniline & Film Corporation to GAF Corporation in 1968. These changes were led by Jesse Werner, appointed chief executive officer by Attorney General Robert Kennedy in 1961. Werner was the first scientist to head General Aniline, and in 1965 become president, and soon after chairman of the board, of the privatized corporation.

In 1968, sales of colorants were averaging US$40 million annually, and General Aniline was second only to Du Pont in this sector. U.S. vat dye production in 1969 exceeded 23,036 tons, of which GAF was responsible for around one quarter. Vat dyes represented one third of Linden capacity. However, the Kennedy round of tariff negotiations concluded in 1967 had introduced cuts in duties on imported dyes and pigments. This took place at the rate of a 10 per cent cut each year over five years beginning in 1968. It slowed down, but did not altogether stop, research into colorants for synthetic fibres, plastics, paper and printing inks, though General Aniline completely neglected fibre-reactive and heat transfer dyes. The former were introduced by ICI in 1956, and soon threatened the market for vat dyes. In 1968, Edwin R. Cowherd, vice president of GAF, testified at a Congressional hearing on tariffs that ‘The cut in the tariffs that has already occurred as a result of the Kennedy Round, and the prospect of the cuts yet to come, have caused us to greatly accelerate the elimination of dyestuffs and pigments from our line.’ The reciprocal lowering of trade barriers in Europe was of no help to GAF and other U.S. producers who for years were content with the growth of the domestic market.

The surfactants, however, saw considerable expansion. Phosphate ester surfactants had been manufactured at Linden from 1958. Around a decade later, Linden modified the manufacturing equipment with the intention of providing improved quality, lower costs and increased capacity. The new chlorine-caustic unit that had been dogged with teething problems began operation early in 1970.

In 1970, Jesse Werner announced that 1969 consolidated net sales rose 6 per cent over the preceding year to US$606,254,000. Chemicals represented 26.9 per cent of total. However the rate of sales growth had fallen due to intense competition. There were extraordinary write-offs due primarily to the scheduled closing of two operating facilities, one a dyestuffs intermediate unit at Linden, and the other a gypsum mine and wallboard manufacturing plant. Competition had reduced sales and profitability of dyestuffs.

Also in 1970, the Verona Dyestuff Corporation, since 1957 the U.S. affiliate of Bayer, built a new dyes plant in Charleston, South Carolina. This contributed to industry over capacity, especially in the large volume vat and disperse dye sectors. Meanwhile, growing textile imports slowed demand for dyes in the United States. These factors lowered selling prices and profits for the U.S. producers. In 1973, the Justice Department charged the major producers with price fixing, which resulted in US$15 million in fines for Allied Chemical, American Color & Chemicals, American Cyanamid, BASF Wyandotte, Ciba-Geigy, Crompton & Knowles, Du Pont, GAF, and Verona.

Dr. Heinz Machatzke, president of Verona Dyestuffs during most of the following decade or so, explains that Verona estimated a 1976 U.S. dye market of US$685 million, US$475 million for textile dyes and US$210 million for non-textile dyes and optical brighteners. There were 17 major competitors who shared 93 per cent of the business and another 18 smaller suppliers with a combined 7 per cent of the market. GAF was ranked ninth, with a market share of 5.4 per cent. Ciba-Geigy was in first place, with 11.8 per cent, Du Pont, second, with 9.9 per cent, and Verona, third, with a share of 9.3 per cent. In 1978, Verona had estimated GAF’s colorant business at US$31 million (US$20 million textile, US$11 million non-textile) with a
share of 3.7 per cent of a total market of US$805 million. Machatzke does not consider that Verona’s growing strength in the market was the single factor in GAF’s withdrawal, though it may have been significant. GAF, with old manufacturing equipment, some dating back to the 1930s, and limited or no R&D left, could not effectively compete in the highly fractured market. The same could be said of American Cyanamid at Bound Brook, with its outmoded equipment, and problematic continuous processes.

All U.S. dye makers had cut research expenditures due to rapidly declining profits. During the period 1961-1980, non-American companies were issued 700 U.S. patents in the new disperse dye class compared to only 292 issued to American companies.¹¹¹ GAF obtained its last disperse dye patent in 1970. Former research chemist Ben Freyermuth says that by this time Easton was termed unproductive by the company. After thirty years of discoveries in all fields of chemistry, the Central Research Laboratory in Easton was closed in 1972. Research and other corporate functions were then consolidated in the Wayne, New Jersey, complex that GAF purchased from Uniroyal Corporation in 1969.

New environmental regulations, introduced from 1970, had forced GAF to make major wastewater treatment and air pollution control investments at Linden and Rensselaer. By 1977 the company had borrowed US$14 million for these projects, with US$10 million allocated to Linden primarily for a new biological, or activated sludge, wastewater treatment plant, located at the east of the plant, close to the Arthur Kill.¹¹²

In mid-1977 GAF announced plans to withdraw from the dye business altogether. In January 1978 the company came to an agreement in principle to sell the Rensselaer plant to the newly-formed Rensselaer Color Corporation.¹¹³ Just before the deal was closed, Rensselaer Color made a forward looking presentation to Rensselaer plant employees on a Friday. But when employees came to work the following Monday, they were surprised to learn that BASF had put the winning bid together over the weekend.¹¹⁴ The sale was finalized on 31 March 1978 and involved approximately US$21.2 million in cash for inventory and accounts receivable and a US$2.5 million note. GAF retained responsibility for debt service on US$3.1 million in pollution control bonds. BASF assumed certain other pollution control obligations. The sale included the buildings, equipment and GAF patents.¹¹⁵ It represented the beginning of a consolidation phase of the market.

The Linden plant had already started to shrink in 1972 with the spin-off of the chlorine-caustic soda operation to Linden Chlorine Products, or LCP Inc., headed by Christian Hansen, a former GAF executive. In 1978 all GAF production ceased except for some photographic dyes and surfactants, but these lines were eventually shut down or sold to other companies. The surfactant business, that represented some 90 per cent of remaining GAF Linden production (the rest was refining of tetrahydrofuran, and production of Gafquat copolymers for detergents, etc., made from vinyl pyrrolidone and alkyl methacrylates), was sold to Rhône-Poulenc Specialty Chemicals in 1990. The Linden site was operated for Rhône-Poulenc products until April 1991, then shut down. In 1989, Samuel J. Heyman, CEO of GAF Corporation since 1983, engineered a leveraged buyout, and GAF became a private concern. In 1991 it became the publicly owned ISP (International Specialty Products) Corporation. GAF was spun off as a roofing material specialist.

In the mid-1980s, the New Jersey Hazardous Facilities Siting Commission tried to site a hazardous waste incinerator in New Jersey. After the Commission rejected several proposed locations, GAF recommended the hazardous waste incinerator be located at its dormant 145-acre Linden site. This would give GAF a way to contain its costs during the remediation of the seriously contaminated site. GAF would use the incinerator to cleanup the site as well as handle the wastes generated by other plants in the area. It offered to build the US$80 million, 65,000 tons a year incinerator which was claimed to have a combustion efficiency of 99.99 per cent.¹¹⁶

Neighbourhood opposition to the incinerator plan was vociferous. Residents of the Tremley Point area, living in the homes originally built after World War I by the Grasselli Chemical Company, were especially concerned with health impacts. The residents were now better educated, represented new ethnic and racial groups, and were no longer dependent on the nearby chemical industries for their livelihoods. They were not afraid to criticize industry and demanded that the GAF site be cleaned up.

GAF and its successor company ISP Corporation, latterly through ISP-Environmental Services, fought for twelve years but failed to obtain the permit for the hazardous waste
incinerator. In 2001, the Hazardous Waste Facilities Siting Commission concluded that New Jersey did not need an incinerator after all. The closure of many chemical plants in the state had significantly reduced the generation of hazardous waste.\textsuperscript{117} The surrounding plants, including LCP, Du Pont and American Cyanamid, had also closed in the interim.

In 1989, GAF signed an Administrative Consent Order with the New Jersey Department of Environmental Protection to fund a US$7.5 million study of the pollution problems at the site. Prime areas to be investigated were a 10-acre landfill with buried wastes and an unlined ditch system used to collect untreated wastewater. After production ceased, the leaking ditch system continued to capture contaminated surface runoff and effluent from the landfill. Prior sampling had shown widespread soil contamination involving hazardous organic chemicals, cyanide, arsenic and other heavy metals. Groundwater contamination included levels of chlorobenzene at 15,200 parts per billion and phenol at 5,800 parts per billion.\textsuperscript{118} New Jersey alleged the company violated the Water Pollution Control Act and the Spill Compensation and Control Act by poor manufacturing practices over many years. GAF said it operated in accordance with applicable laws at the time.

Twenty-two old General Aniline buildings remained empty at the site for years. They were mostly steel and brick structures as high as 75 feet, built on 30 foot pilings. The last three buildings were finally demolished with explosive charges in 2003.\textsuperscript{119} The ISP remedial action plan included installation of a steel barrier, 18-20 feet deep, in the ground to control shallow groundwater. Deep wells were installed to prevent off-site migration of pollution, and the site has been capped with fill material.\textsuperscript{120} After spending US$37 million on the cleanup, ISP hopes the site can be redeveloped as a distribution center. At the time of writing only the derelict buildings of the former chlorine-caustic soda complex remain. The chlorine-caustic soda operation was based on old mercury cell technology, which resulted in heavy pollution of soil, groundwater and a nearby creek with mercury. LCP went bankrupt and the site is scheduled to be remediated under the Superfund scheme.

BASF shutdown the Rensselaer plant in 2000 and moved dye production to Mexico and Germany. After 118 years of continuous operation, apart from a few months in 1915, the plant whose dyes had colored Windex glass cleaner blue, fiberglass insulation pink, and telephone pages yellow was gone.

Conclusion

When the Grasselli Chemical Company began the manufacture of synthetic dyes in 1915, it was to satisfy the strategic and consumer needs of a world at war. There was no time for analysis or assessment of technologies, and even less for understanding the underlying chemistry. This brought profits at first but problems once the war was over, as demand and prices collapsed. German firms had been the leaders in this business and during the 1920s provided the answers to survival capabilities, based on markets and technologies, as well as mutual needs. I. G. Farben enabled the General Aniline Works, later General Aniline & Film, to become a major manufacturer of synthetic dyes in the United States, and certainly the leader in vat dyes, and a force to be reckoned with in azo and sulfur dyes, as well as in surfactants. Then, under the ownership of the U.S. government, research focused on new strategic requirements, particularly involving high-pressure acetylene (Reppe) chemistry. A whole new area for diversification became available. Despite suffering from two major changes of ownership, one the German conglomerate that withheld knowledge, and the other the U.S. government, with its political appointees, General Aniline managed to develop novel products and make them available in the largest consumer and industrial market in the world.

It was not so much the transfer of German technology that made this possible, but as historians Peter Morris and Raymond Stokes have observed, the availability of details of German inventions. General Aniline had an advantage over other American firms that had to rely on postwar Allied investigators, because of the 1940 patent agreement with I. G. Farben.\textsuperscript{121} Even then the path from patents to products was not smooth, though the research sometimes afforded unexpected but profitable outcomes. A good example is in a 1945 report by Easton’s research leader Hanford on one aspect of acetylene chemistry, the polymerization of vinyl ethers: ‘We suspected and subsequently found that the reaction did not proceed by the mechanism given in the patent. We also found that the reaction had much wider application than is covered by the patent.’\textsuperscript{122} This is why the outcome of this and similar episodes, before and after 1942, can only be understood through deliberate discussion of technical details, thereby contributing to the story of the fate of German chemistry in America,
and, as Peter Hayes has described it, ‘toward recovering particular states of the art at given moments.’

The Linden and Rensselaer plants were both closely associated with dyestuffs, and until the late 1960s they were generally successful in that sector. The subsequent rapid loss in market share arose from several factors, and not just the reduction in tariffs carried out from 1968. They included the facts that: there was a shift towards building materials in 1967, following the acquisition of Ruberoid (sometimes referred to as a merger); research spending was cut, which hampered the development of new dyes needed by the textile industry; and burdensome environmental control investments mandated by the new EPA regulations. Then of course there was the prospect of greater profits to be had from quite different markets, often satisfied by diversification based on what had originally been I. G. Farben inventions.

Today GAF is a major manufacturer of roofing materials that sees its long heritage in Ruberoid, founded in the 1880s. ISP, owner of the vacant site at Linden, is a major international manufacturer of specialty chemicals, including of surfactants and products that arose from research into acetylene chemistry, and special-purpose iron powders. In many ways this represents the chemical legacy of I. G. Farben in America.

Acknowledgements

The following are thanked for providing information that has been useful in the preparation of this article: James Bohning, Harlan B. (Ben) Freyermuth, Ned Heindel, Heinz Machatzke, Peter J. T. Morris, Declan O’Reilly and Leander Ricard.

Notes

[16] ENSR, ‘Article X.’
[23] The other members were Martin H. Glynn, former New York governor; L. J. Hardy, former New York City corporate counsel; and Nicholas F. Brady, a financier. Haynes, American Chemical Industry, vol. III, 259.
[28] Hendrick, 'Record of the Coal-Tar Color Industry.'
[29] Ricard, 'History of the Dye Producing Industry.'
[32] Schmidt, 'Foreign Trade Strategies.'
[34] 'Grasselli Company Claims To Be Losing on $4,500,000 Dye Investment,' *Chemical and Metallurgical Engineering* 26, no. 13 (29 March 1922): 610.
[35] Watson, 'Progress in the Domestic Manufacture.'
[37] 'Dye Invasion Feared,' *Indianapolis (Indiana) Star*, 23 June 1924.
[40] Ricard, 'History of the Dye Producing Industry;' Ney and Van Marie, 'Processes.'
[41] Hager and Marsson, 'Developments in the Naphtol AS Series.'
[42] Rath, 'New Developments in Naphtol AS.'
[48] Draves, 'Manufacture of Anthraquinone Vat Dyes.'
[51] 'New Indanthrene Made By General Aniline,' *American Dyestuff Reporter* 18, no. 10 (10 June 1929): 404; 'New Indanthrene Blue Announced,' *American Dyestuff Reporter* 18, no. 11 (24 June 1929): 452; 'Announce Several New Dye Products,' *American Dyestuff Reporter* 18, no. 14 (19 August 1929): 573. The best technical account of the vat dye processes is Bradley and Kronowitt, 'Anthraquinone Vat Dyes.' As mentioned in the text, Kronowitt worked at Linden until the late 1940s, when he joined Ciba States.
[53] Glaser-Schmidt, 'Foreign Trade Strategies.'
[56] For amino resins, see Travis, *Dyes Made in America*, 115–24.
[57] Kastens and Ayo, 'Pioneer Surfactant.'
[64] The other four were Hans Aickelin, vice president in charge of research and a former director; William vom Rath, vice president of aniline dyes production and a former director; F.W. von Meister, general manager and director of the Ozalid division; and Leopold Eckler,


[70] Leander Ricard, personal communication, March 2005.


[76] Aniline Dyegest 2, no. 2 (June–July 1946): 1, 2.

[77] Kastens and Ayo, ‘Pioneer Surfactant.’


[81] Copenhaver and Bigelow, Acetylene; Bigelow, ‘Reppe’s Acetylene;’ Golding, Polymers and Resins, 523–7.


[83] Ross, ‘General Aniline.’


[90] Ross, ‘General Aniline.’ For another example of state-controlled chemical industry in the USA, see Morris, Synthetic Rubber.


[92] ‘GAF Lab To Remain Here Despite Some Transfers,’ Easton (Pennsylvania) Express, 14 January 33 1955.


‘Wage Hike Given,’ *Post Standard* (Syracuse, NY), 30 August 1949.


Mock, ‘The Textile Dye Industry.’


Wm. Sword & Company, an international banking company of Princeton, New Jersey, was the sole owner of Rensselaer Color. William Sword, a board member of GAF, was managing director of the banking firm, which had a key role in establishing Buffalo Color Corporation in 1977 when Allied Chemical divested its dyes operations. ‘GAF Unloads Dyestuff Plant,’ *American Dyestuff Reporter* 67, no. 1 (January 1978): 14.

Leander Ricard, personal communication, April 2005.


Hayes, ‘I.G. Farben Revisited.’

References


Birnpee, George W. General Aniline & Film Corporation. Report to the Hon. Leo T. Crowley and The Hon. James E. Markham, 11 April 1944.


ENSR. ‘Article X Case No. 00-F-2057. NYSDEC Project No. 4-3814-00052.’ ENSR International, Empire State Newsprint Project. ENSR: Westford, Massachusetts, December 2001.


I.G. Farbenindustrie Aktiengesellschaft 1930, Frankfurt am Main, 1930.


