UNLIKELY VICTORY:

HOW GENERAL ELECTRIC SUCCEEDED IN THE CHEMICAL INDUSTRY

by Jerome T. Coe

Published by the American Institute of Chemical Engineers
3 Park Avenue, New York, NY 10016-5991

In Association With
The Chemical Heritage Foundation
315 Chestnut Street
Philadelphia, PA 19106-2702
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The path by which General Electric (GE) became a major factor in the chemical industry is a fascinating story for those of us who worked in that part of the company and who have followed its progress in later years. GE’s chemical industry products—engineering plastics, silicones, and synthetic diamond make up one of the major growth areas for the company in the post–World War II era, the notable others being financial services and aircraft jet engines. These three nonelectrical segments now account for well over half the company’s revenues and earnings. The chemical products are not only an important part of GE, but they place it in the top ranks of U.S. chemical industry producers.

I will review the major chemistry discoveries, technology developments, marketing programs, and the management initiatives, or strategies, which together created the large and successful endeavor now called GE Plastics. I will also chronicle some individuals who played key roles in these teamwork efforts.

My GE career began in 1942 in the Research Laboratory, where I joined the silicone project as a chemical engineer after graduating from M.I.T. After service in the navy, I rejoined GE in 1946. The company was then building a silicone plant at Waterford, N.Y. After some years managing silicone process development and manufacturing engineering, I headed sales development, then field sales, and finally marketing. I was general manager
of GE Silicones from 1959 to 1964, after which I led GE's computer services business (called "time-sharing"), and then I headed a division that included diamond manufacturing. Strategic planning and corporate staff assignments completed my 40-year GE career.

My point of view in this history, which describes GE's chemical industry experience during more than half a century, is that of general management: how are the people, technology, and investment assets of a business employed to serve customers profitably in a market, in competition with other organizations equally well staffed and financed? What discoveries were made? What initiatives were chosen by the managers? How well did these choices work out? What lessons did GE managers learn and how were these applied in later programs? The principal measures of the success of such efforts are sales, sales growth, share of the market, and the rate of income return on sales and on assets. While this is a General Electric story—GE disappointments as well as accomplishments are described—I have tried to present competitive perspective realistically.

This work is not a company-authorized history, although top executives encouraged me and have cooperated with interviews and assistance. Judgments on content and emphasis are my responsibility, as are inadvertent errors.

I hope this book will serve three groups of readers:

1. Chemists, chemical engineers, industry executives (and their former professors), who are interested in how GE's chemical discoveries and technology developments were profitably matched to market opportunities; in short, "How'd they do that?"

2. Students and teachers of business management practice attracted by the management lessons GE learned along the way.

3. General Electric employees, present and retired, who want to know, or remember, how this part of the company evolved and became successful.

GE now refers to its major businesses descriptively, for example, GE Plastics, GE Aircraft Engines, GE Lighting; and the leaders of the large units are now titled President and Chief Executive Officer. GE Plastics includes the present chemical products of this history. GE Plastics' overall financial results have been visible since 1984 when the company's annual report first presented data for a Materials business segment. This segment's title was changed to Plastics with the 1998 annual report. This segment's data are essentially synonymous with GE Plastics, as well as with my descriptor, GE's chemical industry products. GE does not regularly release financial information on product lines in greater detail than the annual report breakdown,
but enough news articles, papers, books, oral histories, and personal recollections are available from which to construct a coherent history of GE Plastics with some financial perspective. Whereas the annual reports refer to an **engineered** plastics product line, I have used the more common industry term, **engineering** plastics.

Not every chemical or process industry participation by GE is included here. For example, outside this book's scope GE Lighting makes phosphors for fluorescent lamps, processes ore for making tungsten and tungsten wire, and makes the special ceramic used in high-intensity discharge lamps. In addition to melting quartz to form special lamp envelopes, GE Lighting also sells quartz crucibles that are widely used in hyper-pure silicon zone-refining furnaces.

In the 1930's both the GE Schenectady and Pittsfield Works formulated, formed, and baked large ceramic insulators needed for electric power generation, distribution equipment, and electric utility transmission lines. These insulator plants were later closed, but GE acquired majority ownership of the Locke Insulator Co. of Baltimore, Maryland. This company was finally sold to Japanese interests.

General Electric succeeded Du Pont in 1946 as contractor to the Atomic Energy Commission for the Hanford, Washington, nuclear facilities, and resigned that role in 1964. At one time GE designed and built for the AEC a spent nuclear fuel reprocessing plant that was subsequently shut down. GE's commercial nuclear energy business fabricates nuclear fuel reloads for existing power plants and for the occasional new facility.

A GE department once made space reentry vehicles, and developed pyrolytic graphite carbon polymers to protect the vehicle entering the atmosphere.

The Loctite chapter is included, not just because a GE research discovery and an alumnus played a part, but also because the Loctite Corporation's chemical innovation success demonstrates management lessons similar to those from GE's product experiences.

I have not dwelt on all the (sometimes bewildering) changes in GE organization and its nomenclature, but have mentioned those most relevant to this chemical business. The early Research Laboratory became Corporate Research and Development Center, or C. R.&D. I have used these terms interchangeably. Works Labs became Materials and Processes Labs, but I have stayed with the earlier term. Chemical **Division** is used here rather than its earliest designation as **Department**. Chemical Development **Operation** is cited rather than the earlier Department. (Also see Appendix C on GE organization.)
No attempt has been made to trace all personnel changes in various positions, but the path of some individuals is presented so their GE background or their progress to other parts of the company can be understood. Contributions of many people will be cited, and brief biographies of key scientists and managers are presented.

*Business strategy* is the sum of decisions made by the business managers, the term usually meaning decisions with long-term impact. A successful strategy, competently carried out, establishes a competitive advantage of some duration. Business success flows not only from the strategy chosen, but also from organizational competence to carry out the plan. So both the game plan and the execution are critical. GE's effectiveness in managing chemical businesses grew greatly with experience, as this book demonstrates. Scientific discovery, technology development, creative marketing, and management strategies all played a role in the success. I have emphasized those discoveries, events, and strategies that were most important to the present outcome.

Jerome T. Coe
Greenwich, Connecticut
May 15, 1999
I am deeply indebted to many individuals for their contributions to this book through recollections, referrals, comments on drafts, writings, and formal publications.

George Wise, formerly of GE’s Corporate Research and Development Center, has been especially helpful with editorial suggestions, references, and historical knowledge of both the R&D and commercial aspects of GE’s chemical business. He is the author of *Willis R. Whitney, General Electric, and the Origins of U.S. Industrial Research* (Columbia University Press, 1985). He also provided the complex history of diamond making, including the early GE discoveries.

Charles Reed, who retired as Senior Vice-President–Technology of General Electric in 1979, gave me much encouragement and shared extensive recollections from his 37 years with GE, most of them associated with the silicones, diamond, and engineering plastics businesses.

Jack Welch, GE’s Chief Executive Officer, encouraged me to write the book, as did Gary Rogers, CEO for GE Plastics, and each granted interviews.

Chemical Heritage Foundation Oral Histories from Daniel W. Fox, Allan S. Hay, Charles E. Reed, Eugene G. Rochow, J. Franklin Hyde, and Earl L. Warrick, were an important resource, as were Liebhsfsky, *Silicones Under the Monogram*, (John Wiley, 1978) and Morone, “New Business Development and General Managerial Decision Making,” *Research on Technological*
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Innovation, Management (JAI Press, 1993). Leonard Fine, author of Chemistry for Nonchemists, A Practical Guide to the Science and Technology of GE Plastics (unpublished) provided several important personal recollections. These and many other relevant writings, both published and unpublished, are noted in the Chapter References section.

The book's content editor, Otto T. Benfey, made significant contributions that improved the clarity of presentation, arrangement of subject matter, and technical details throughout the whole document.

I'm indebted to Stephen Smith and Gail Nalven of AIChE Publications for early encouragement and later commitment to publish this work of a first-time author. Many thanks also to the AIChE team of Beth Shery Sisk, Trumbull Rogers, and Terry Baulch for bringing the manuscript to publication.

It has been gratifying to renew so many acquaintances with friends and former business associates. I was able to make some contacts in person, but many were by lengthy telephone conversations. Individuals who made special inputs are noted with the references for each chapter, and I am grateful to all the following who provided input, insights, and help:


I am very grateful to my dear wife, Peggie, who encouraged me during several years of effort, and who also launched me toward computer competence, without which the task would have been impossible.
What's General Electric Doing in the Chemical Business?

How did General Electric, an electrical manufacturing company, become one of the largest and most successful U.S. chemical companies?

Successful long-term diversification is rare among giant U.S. companies. Many tried: Exxon for a while sold electric motors and office computers, but is now again an oil and petrochemicals company. General Motors tried refrigerators, Ford tried electronics, and Chrysler made tanks and corporate jets; they are now more narrowly focused car companies. AT&T, after long ago being a competitor of GE in electrical machinery and later making a major try in computers, is again a telephone company. It has recently spun off its equipment design and manufacturing business, and is acquiring cable TV companies.

The conventional wisdom has usually argued against wide corporate diversification. Andrew Carnegie in the 1880s said, "Put all your eggs in one basket and watch that basket." Tom Peters and Robert H. Waterman in their 1980s bestseller In Search of Excellence, said "Stick to the Knitting." For a time in the 1960s, conglomerates became fashionable, but the subsequent difficulties of such leaders as Textron, RCA, and ITT only underlined the earlier wisdom.

GE has spent over a century ignoring that conventional wisdom. Its businesses now include financial services, currently the largest earnings contributor, aircraft jet engines, television broadcasting, information services,
plastics, medical equipment, as well as light bulbs, turbines, transformers, switchgear, electric motors, and appliances. It is now classified by Business Week as a Conglomerate. Compare it with the others on this magazine's (1996) conglomerate list.\(^2\) GE's sales are more than five times as great as the next largest conglomerate, Allied Signal, and its earnings are more than twice as large as all the other eleven conglomerates on the list put together.

So GE's diversity is both successful and surprising. How was it accomplished? GE did not always achieve diversity from strategy, but sometimes from necessity. In chemistry, for example, it became good at making polymers in order to keep electricity in wires. Those chemical interests eventually stimulated research in the field of engineering plastics, the high-performance end of moldable plastics. Then, as much to its own surprise as anyone else's, GE found itself in a position to grow a worldwide business, so technically complex and so capital-intensive that competitive entry was difficult.

It was not the outcome of a conscious long-range plan. It was not directed from corporate headquarters by a bureaucracy. It was guided for some decades by a small number of individuals acting as a small business, tucked away in a corner of the corporation. Much of what they did was counter to the then prevailing GE culture. Today it has become the corporate culture. In part, this is because one of those pioneers in the GE hinterlands, Jack Welch, is now GE's Chairman and Chief Executive Officer. Not many remember that John F. Welch, Jr., got his start in the GE plastics business, which he joined after receiving a Ph.D. in chemical engineering from the University of Illinois.

Although the magnitude of GE's chemical participation is not widely known, competitors in the industry niche called "engineering plastics" are well aware that GE is the world leader in these thermoplastics. Within GE, recognition of the size, scope, and contribution of this business was scarcely noticed until fairly recently. But beginning with 1984, GE annual reports\(^3\) show segment financial data for "Materials," now retitled "Plastics," which comprises: High-performance engineered plastics used in applications such as automobiles and housings for computers and other business equipment; ABS resins; silicones; superabrasive industrial diamonds; and laminates. Sold worldwide to a diverse customer base consisting mainly of manufacturers.

GE's 1998 sales from these chemical-type products were $6.6 billion, operating profit was $1.58 billion, and assets employed were $9.8 billion. The recent Plastics sales are comparable to GE's aircraft jet engines, major appliances, or power-generation businesses. Plastics' profit contribution has been comparable to aircraft engines and is greater than power generation, appliances, NBC broadcasting, or lighting products. Assets employed in
What's General Electric Doing in the Chemical Business?

these chemical-type businesses (year-end 1998) are greater than any other GE manufacturing segment, showing both that the chemical businesses are capital-intensive and that GE has been willing to invest heavily in this arena.

In 1948, three years after a GE Chemical Division was first formed, its contribution to company external sales was around 1.5% and to profits was nothing. So over a 50-year period, GE's chemical business grew from negligible contribution to a 7% sales and a 12% profit share within the corporation. In the same period, General Electric's total revenues grew 61-fold to $100.5 billion, earnings grew 66-fold, and its stock market valuation reached number one among U.S. corporations (currently No. 2 behind Microsoft).

The organization now responsible for these products is GE Plastics, which includes not only the engineering plastics and ABS resins but also Polymerland, a distributor of many plastics, a petrochemical styrene producer, and a phosphite plastics additives product line. GE Silicones, GE Superabrasives, and GE Electromaterials are separately managed businesses, also within the GE Plastics structure.4

Engineering plastics and the related products and services are by far the largest and most important of the GE Plastics products. These thermoplastics are specially crafted by chemical polymer engineering to meet one or several high-performance specifications, such as strength; heat and cold resistance; impact strength; dimensional stability; oil, solvent, or moisture resistance; durability in sunlight; and many other properties needed for different applications in the manufactured-products world. Engineering plastics prices are higher than those of the high-volume commodity plastics and are produced in much smaller tonnages. The automotive, appliance, computer, telecommunications, electronics, and construction industries are major end users of engineering plastics parts.

GE is the overall global leader in engineering plastics by a wide margin, almost twice as large as the nearest producer. The major world competitors in this niche include Du Pont, Celanese, Bayer, BASF, Dow Chemical, and Mitsubishi Gas Chemical.

The most important GE plastics product lines are:

LEXAN polycarbonate resins (PC), plus glazing and film;
NORYL modified polyphenylene oxide (PPO) resin alloys;
VALOX polybutylene terephthalate resins (PBT);
XENOY PC/PBT resin alloys;
CYCOLAC acrylonitrile/butadiene/styrene (ABS) resins;
CYCOLOY PC/ABS alloys;
ULTEM polyetherimide (PEI) resins.
World headquarters for GE Plastics is Pittsfield, Massachusetts. Major polymer manufacturing plus compounding facilities are located throughout the world: in the United States (8 locations), The Netherlands, Spain, Germany, and Japan (4 locations). Additional plastics compounding is conducted in Canada, Mexico, Brazil, Argentina, Scotland, France, Italy, South Korea, Singapore, China, and India. In addition to the Pittsfield and Netherlands headquarters, twelve commercial development technical centers are located in the major industrial countries of the world.

**GE Silicones** is another important segment of GE Plastics. The product lines comprise dimethylsiloxane fluids of many viscosities and various volatilities, fluid-water emulsions; silicone rubber gums and compounds; sealants and caulking materials, plus other liquid-rubber products from a family of room-temperature vulcanizing (RTV) silicone compounds; silicone resins in solvent solution; and many other silicone specialties. GE Silicones headquarters and main plant are at Waterford, New York. Rubber compounding capacity is also located in The Netherlands. GE Toshiba Silicones (Tosil) is a joint venture in Japan, as is GE Bayer Silicones in Europe.

The world volume leader in silicones by a wide margin is Dow Corning, with GE (including the Tosil and Bayer joint ventures) in second place. Other major world producers include Shin Etsu (Japan), Wacker-Chemie (Germany), Rhodia (France), and Witco.

**Superabrasives** include a range of small synthetic-diamond crystals, the finer mesh sold to make diamond grinding wheels, and the larger to manufacture diamond saws. Diamond polycrystalline compacts, or blanks, made in various shapes from cemented diamond crystals, are used to make wire-drawing dies, special cutting tools, and oil exploration bits. Borazon, a cubic boron nitride, forms special grinding wheels, and Borazon compacts machine special steels. The GE Superabrasives headquarters and main plant are at Worthington, Ohio, and a second major plant is in Ireland. GE is considered the world leader in synthetic-diamond products, but De Beers Consolidated Mines, Ltd., is a major competitor worldwide in these superabrasives.

The *laminates* products offered by **GE Electromaterials**, are layers of glass fiber bonded by various resins and formed under pressure and heat into tough sheet materials having excellent electrical insulation value. The laminates are usually copper clad to form baseboards for electronic printed circuits. The sales contribution of this product line is now small in the GE Plastics total. GE Electromaterials headquarters and plant are at Coshocton, Ohio.
What's General Electric Doing in the Chemical Business?

When the 1984 GE Annual Report broke out the chemical business data for the first time, many within GE were surprised by its size and earnings contribution. The breakout also made it possible to assess GE's chemical activity in relation to others in the chemical industry. *Chemical and Engineering News* has since 1968 published a special ranking of the leading U.S. chemical producers (originally 50, then 100, now the top 75). The data are derived from annual reports of companies with chemical-type businesses or product lines. The *Chemical and Engineering News* presentation subtracts from corporate totals such segments as petroleum industry participation, metals production, and consumer product sales, but it includes chemicals, fibers, and plastics. For Du Pont, its chemicals, fibers, and polymers segments have been included, but not its petroleum, pharmaceutical, or diversified businesses. Dow Chemical data have included all segments except its consumer specialties. Monsanto's data in this analysis (prior to the Solutia spin-off) included its Agricultural and Chemical Groups, but not Searle or NutraSweet. The magazine cites the “plastics” data above for General Electric.

The *Chemical and Engineering News* listings of U.S. chemical producers in 1968 and in 1998 by chemical sales show the following:

<table>
<thead>
<tr>
<th>Rank</th>
<th>1968</th>
<th>1998</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Du Pont</td>
<td>Du Pont</td>
</tr>
<tr>
<td>2</td>
<td>Monsanto</td>
<td>Dow Chemical</td>
</tr>
<tr>
<td>3</td>
<td>Union Carbide</td>
<td>Exxon</td>
</tr>
<tr>
<td>4</td>
<td>Dow Chemical</td>
<td>General Electric*</td>
</tr>
<tr>
<td>5</td>
<td>W. R. Grace</td>
<td>Union Carbide</td>
</tr>
<tr>
<td>6</td>
<td>Exxon</td>
<td>Huntsman*</td>
</tr>
<tr>
<td>7</td>
<td>Celanese</td>
<td>ICI America*</td>
</tr>
<tr>
<td>8</td>
<td>Allied Chemical</td>
<td>Praxair*</td>
</tr>
<tr>
<td>9</td>
<td>Hercules</td>
<td>BASF*</td>
</tr>
<tr>
<td>10</td>
<td>Food Machinery</td>
<td>Eastman Chemical*</td>
</tr>
</tbody>
</table>

While this ranking in recent years has been affected by spin-offs, mergers, and acquisitions, General Electric is currently (1998) the highest ranked of the six asterisked new entries to the top-ten chemical sales list.
In 1968 GE's chemical-type product sales were around $300 million, which, had they been publicly visible at the time, would have made a *Chemical and Engineering News* ranking of No. 29. By 1984, GE had become a more significant player in the chemical industry: in that year's analysis GE ranked No. 15 in sales, No. 6 in operating profit, No. 9 in assets, and was shown to be a leader in both ratio of profit to sales and profit to assets.

In 1993, surprisingly, GE was first in profit:5

<table>
<thead>
<tr>
<th>1993 ($ mills)</th>
<th>Chemical Sales</th>
<th>Chemical Operating Profit</th>
<th>Chemical Assets</th>
</tr>
</thead>
<tbody>
<tr>
<td>Du Pont</td>
<td>15,603</td>
<td>750</td>
<td>13,957</td>
</tr>
<tr>
<td>Dow Chemical</td>
<td>12,524</td>
<td>773</td>
<td>12,530</td>
</tr>
<tr>
<td>Exxon Chemical</td>
<td>10,024</td>
<td>638</td>
<td>8,478</td>
</tr>
<tr>
<td>Hoechst Celanese</td>
<td>6,347</td>
<td>561</td>
<td>NA</td>
</tr>
<tr>
<td>Monsanto</td>
<td>5,651</td>
<td>731</td>
<td>5,312</td>
</tr>
<tr>
<td><strong>General Electric</strong></td>
<td><strong>5,042</strong></td>
<td><strong>834</strong></td>
<td><strong>8,181</strong></td>
</tr>
<tr>
<td>Union Carbide</td>
<td>4,640</td>
<td>354</td>
<td>4,419</td>
</tr>
</tbody>
</table>
What's General Electric Doing in the Chemical Business?

The 1993 comparisons are not typical for the major competitors, as a recession that year depressed profits severely for many. The much larger chemical sales of Du Pont, Dow Chemical, and Exxon Chemical will ordinarily prevail in the profit column also. But recent GE Plastics sales and operating profit consistently rank high among U.S. chemical producers:

<table>
<thead>
<tr>
<th></th>
<th>Chemical Sales Rank</th>
<th>Chemical Operating Profit Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>1998</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>1997</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>1996</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td>1995</td>
<td>6</td>
<td>5</td>
</tr>
<tr>
<td>1994</td>
<td>6</td>
<td>4</td>
</tr>
<tr>
<td>1993</td>
<td>6</td>
<td>1</td>
</tr>
<tr>
<td>1992</td>
<td>7</td>
<td>2</td>
</tr>
</tbody>
</table>

Special recognition of these industrial achievements came with a 1991 National Medal of Technology award to Charles E. Reed, a retired senior vice-president of General Electric, whose 32-year career with GE was largely devoted to the creation and growth of the company's chemical business. This medal is presented annually by the nation's president to individuals and companies for their outstanding contributions to improving the well-being of the United States, either through development or commercialization of technology or for their contributions to the establishment of a technically trained work force.

Reed's medal citation reads:

For his management risk-taking in continuous innovation leading the General Electric company to world class production of advanced engineering materials.

Starting from a negligible industry position in 1945, the magnitude of GE's success was unexpected both inside and outside General Electric, because GE's chemical business developed slowly from a faltering start. But as competitive competence increased within the organization, GE marketed innovations in *silicones*, *synthetic diamond*, and then *three engineering plastics*, becoming leader in the latter niche of the plastics industry and reaching the top ranks of U.S. chemical producers. The remarkable outcome to this point stems from technical innovations, successful leadership, and manage-
ment strategies that were implemented by the organization more and more effectively as time went on. In the 50-year effort a large number of scientists, engineers, salesmen, and managers all made essential contributions to the success of these high-technology businesses.

By entering the chemical business and investing heavily in it over the years, GE clearly did not “stick to the knitting,” at least as knitting would be defined by the company’s product scope of 1945. For a long time the chemical effort was not a big corporate success, even skirting failure in the early years. But, in the long run, General Electric’s rise to the top ranks of the U.S. and world chemical industry is a remarkable and unexpected achievement. How this unlikely victory was accomplished is the story of this book.
General Electric Company emerged as a major corporation because Thomas Edison did more than just invent a better light bulb. He embedded it in a system for lighting and powering the world. The system created the electric utility industry. The supplying of equipment for the system created GE, founded as a merger of Edison’s company and some rivals in 1892.

GE became involved with chemistry because the wires, connectors, and equipment that carried and used electricity had to be insulated: that is, covered with something that kept the electricity in. Edison’s workers used various kinds of natural materials or their derivatives to do this job: wood oil, shellac, mica, paper, cloth, and rubber. GE continually searched for new solids, liquids, and rubber materials that would block the leakage of electric current. The effort was carried on in the corporate Research Laboratory and in labs attached to GE plants (called Works) in Schenectady, New York; Pittsfield and Lynn, Massachusetts; and Ft. Wayne, Indiana.

In 1906, an independent inventor, Leo Baekeland, invented a thermosetting plastic with unusually good strength, rigidity, and electrical insulating characteristics. This material, later trade named Bakelite, has often been called the world’s first truly synthetic plastic. Other plastics had been made by re-forming natural materials, but this one started from simpler chemicals, phenol and formaldehyde. Both as a liquid resin and as a molding com-
Unlikely Victory: How General Electric Succeeded in the Chemical Industry

pound, Bakelite was an improvement over its natural predecessors.

In 1909, Baekeland brought his invention to a fellow chemist and industrial pioneer, the director of GE's Research Lab, Willis R. Whitney. Whitney had come from MIT in 1900 to GE's Schenectady plant to create the first true research lab in U.S. industry. At the GE Research Lab, which Whitney ran for 32 years, scientists worked alongside engineers and inventors for the first time, and did fundamental research as well as company problem solving. Whitney was a competent colloid chemist, but he soon learned that his real talent was inspiring others. He also understood the purpose of industrial research. "I did not come to Schenectady to create a philanthropic asylum for indigent chemists,"¹ he told the scientists he hired. He inspired them with the value of research, and they left his presence with a strange desire to improve the light bulb—or to find something better to stick on wires to keep the electricity in.

The story of the GE Research Laboratory has been told many times (see Wise, Columbia University Press, 1985¹). Its results have ranged from very practical improvement of the light bulb to Nobel Prize-winning discoveries in surface chemistry (Irving Langmuir) and superconductive tunneling (Ivar Giaever). Whitney realized, however, that no laboratory could invent more than a small fraction of the improvements needed to keep its company a leader. At his urging GE took a license from Baekeland and began using phenolic resins and compounds for many insulation uses.

Another key GE technologist, Charles Steinmetz, also put insulating materials high on his research wish list. Steinmetz, GE's chief consulting engineer and a visionary, cigar-smoking, German-born Socialist, had proposed the research lab that brought Whitney to Schenectady. In 1912 Steinmetz sent a letter to a second GE lab, the Pittsfield Works Laboratory, urging more work on insulation. Specifically, he urged the laboratory's researchers to explore combinations of polybasic alcohols and polycarboxylic acids in a search for flexible insulating resins.² Steinmetz didn't realize he was edging GE toward a promising innovation area of the twentieth century, engineering plastics. That 1912 Steinmetz letter is recognized today as the start of GE's polymer effort. It would turn out to be a marathon, not a sprint.

Electrical Insulation

The GE Works were large multiproduct factories, each product needing many forms of electrical insulation; and the Works management would often choose to manufacture, rather than purchase, the insulations needed. Small copper wires were coated with a baked-on wire enamel, larger cable
Early Years of GE Chemistry: 1900–1948

conductors with an extruded rubber or plastic. The large conductor bars inside motors, generators, and transformers were wrapped with tape insulations of many kinds. Varnished cotton cambric was a common early cable insulation tape, while glass and other cloth tapes, variously bonded, came along in later years. Mica was a key ingredient of both solid insulation forms and tapes, and many varnish types were used to glue the mica flakes together. Insulation varnishes were used for impregnating coils by a dipping, then baking process. Solid insulation spacers were much used in large equipment, and a large quantity of laminates was needed for this purpose. These laminates were made from kraft paper and liquid phenolic resins, formed and cured in heated high-pressure presses. The Schenectady, Pittsfield, and Lynn Works each made laminates, and from them Lynn also fabricated quiet gears and automotive timer components. The Schenectady Works also made insulation varnishes, varnished cambric tapes, and bonded-mica products. The ever-present need for improved electrical insulation stimulated chemistry research in both the Works laboratories and the Research Lab.

Alkyd Resins

In the 1920s an insulation section within the Research Lab explored polyester products from the phthalic anhydride–glycerin reaction, and Roy H. Kienle become a nationally recognized authority on such polymer systems, especially those modified with unsaturated fatty acids. He named these polymers “alkyds,” a designation still used today, and he was granted several important patents. The GE Research Lab effort in this polyester field peaked in 1929 at about 10 researchers. The usefulness of alkyd resins in electrical insulation proved limited, but they became and remain a very important resin base for many industrial and consumer paints.

General Electric licensed the alkyd patents broadly and also set up to manufacture alkyd resins and industrial paints, the latter trade named Glyptal, in Schenectady around 1933. The Du Pont line of Dulux enamels for automotive and appliance finishes, for example, used alkyd resins that Du Pont manufactured under a GE license. GE expanded its alkyd resin capacity in the late 1930s, sold alkyd resins externally to paint manufacturers, and eventually achieved a 5–10% market share. GE managed this business along with Schenectady-located varnishes, tapes, and mica products in an organization called Resins and Insulating Materials Department (RIM).

Molded Plastics: Phenolic Resins and Compounds

After the Baekeland discoveries (patented in 1913), and the subsequent availability of phenolic molding compounds from the Bakelite company, GE
products needed plastic molded parts, and several GE plants set up molding shops for their supply. Two of the earliest large-volume parts were the handle and thumbrest for electric irons and molded bases for vacuum tubes. A molding plant was established in the Pittsfield Works, while phenolic resin and compound development in that Works lab under A. McKay Gifford led to manufacturing facilities for improved phenolics. Output of this Pittsfield (phenolic) compound, resin, and varnish plant was also used by the molding and laminating operations in Schenectady, Lynn, and Ft. Wayne, and by the wiring devices (switches and plugs) business of affiliated Monowatt Company in Providence, Rhode Island.

GE combined the growing molded plastics, laminates, and phenolic resin activities of the company into a single Plastics Department in 1930, with sales representation for both internal and external business. Under the leadership of G. Harry Shill, laminates manufacture was consolidated in the Lynn Works in 1932, while molded parts were made in Pittsfield, Meriden, Connecticut, and Ft. Wayne. The growth of plastics-parts molding led to a large new plant on the outskirts of Pittsfield. This molding plant, a $1 million investment in 1937, and, eventually, containing more than 1000 compression presses, was said to be the largest in the United States in the late 1930s. By the 1940s about half the Plastics Department’s output of molded parts and laminates was for internal use and half was sold to external industrial customers. Phenolic resin and compound manufacture remained in Building 36 of the main Pittsfield Works, which itself was increasingly dedicated to making large transformers. Wartime demands from the GE laminates and molding plants took the full output of this phenolic resin and compound facility, so these phenolic materials were not sold externally until after World War II.

Plastics Department headquarters and part of the development laboratory moved out of the Pittsfield Works in 1937 to a new location, renamed “One Plastics Avenue,” which is still the headquarters location of the GE Plastics world business. The laboratory move to One Plastics Avenue was completed in 1941, and the development staff reached a total of about 75 in 1943.

Under the leadership of Frank D’Alelio and later James J. Pyle, this laboratory yielded some important polymer improvements, including vacuum dehydration of resins and roller grinding of compounds. Phenolic products that were tailored for GE applications proved superior to some available from the larger commercial producers. The GE invention of sulfonated polystyrene materials (D’Alelio) led to significant patents and royalties, though not to manufacture.