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EDITORS’ CORRECTION:
On this page in the Winter 2004 issue of Ohio Valley History, the editors incorrectly associated the Thomas Jefferson Papers with the University of Virginia. In fact, the Thomas Jefferson Papers: Retirement Series is sponsored by the Thomas Jefferson Foundation, and is housed in the Robert H. Smith International Center for Jefferson Studies, at Monticello, Charlottesville, Virginia. Our apologies.
To the Editors

The contributions to this issue of Ohio Valley History were originally presented at a “History of Technology Symposium” that made up part of the 175th anniversary celebration of the Ohio Mechanics Institute/College of Applied Science, now part of the University of Cincinnati. In 2001, Dean Richard Newrock of OMI/CAS requested the cooperation of UC historians to plan a “symposium on the History of Technology” with papers and sessions that would treat both the history of OMI and broader issues of science, technology, and education from the nineteenth century to the present and beyond. With his support and encouragement, a planning committee made up of historians from around the university, including Maria Kreppel, Muthar Al-Ubaidi, and Jason Krupar from OMI/CAS, Judith Spraul-Schmidt from Raymond Walters College, and Tracy Teslow and myself from the College of Arts and Sciences, set to work on the pleasurable task of crafting an event that would do justice to a rich history and promising future.

We were fortunate to be able to call upon the expertise of a number of our colleagues, including Roger Daniels, Zane Miller, David Stradling, and Henry Winkler, and helped by their suggestions several major themes emerged around which we organized the contributions of keynote speakers and session participants. The first was the history of technical and engineering education of which the Mechanics Institute movement in general, and Cincinnati’s OMI in particular, played such a great a role. We decided to divide this theme between sessions and speakers who would deal with either the nineteenth or twentieth century, and treat aspects of the subject both within and without Cincinnati. Our other theme was how technology was displayed to the world through expositions in the nineteenth century and world’s fairs in the twentieth. Once again, OMI was important here as the organizing institution of a series of major technological expositions in Cincinnati. To end our symposium, we went in search of someone with a lively technological vision of the future, who could provide that “Look ahead” into a technologically rich future.

Any conference is an experiment in intellectual and social chemistry, and we seemed to have chanced on a successful formula. Our keynote speakers, Philip Scranton, Rosalind Williams, and Donald Norman delivered stimulating, germane addresses ranging from the economic and industrial history of Cincinnati, through the dilemmas and challenges in the teaching and practice
of engineering in this age of “technoscience,” as well as the coming convergence of technology and emotion in future industrial design. Our session participants both deepened and broadened the symposium’s reach thanks to contributions from Carroll Pursell, Richard Lakes, Alan Marcus, Jeffrey Haydu, Kenneth Chapman, and Bruce Seely, completed by a session composed of papers by Robert Rydell, Judith Spraul-Schmidt, and Tracy Teslow. And also gratifying were the conversations, discussions and exhibitions that took place outside the meeting hall in which members of the audience found a generous and willing reception.

I am personally very grateful to the editors of Ohio Valley History to bring selected results of our March 2004 weekend to the readership of this journal.

James Murray
Chair, OMI/CAS Symposium Committee
A half-century ago, Frederick V. Geier, board chairman of the Cincinnati Milling Machine Company, gave the commencement address at the Ohio Mechanics Institute. Geier’s firm, then and later, shone as one of the brightest stars in the city’s industrial firmament. CMM, or “the Mill” as it was known locally, made top quality machine tools and innovative metal-cutting fluids. It was then, in 1952, beginning an extended collaboration with the Air Force, designing and building experimental tools for fabricating experimental planes, as well as starting to venture into designing machinery for a rapidly expanding plastics industry. In his address to the graduates, Geier looked both back and forward:

Some of us here tonight grew up in the days when barbed wire fencing and wire nails were new. Booming new industries . . . were the railroad, the air brake, the automatic coupler, and the automatic switch and signal, not to mention the low wheel bicycle and the bicycle built for two. The marvels of the times were the electric incandescent light bulb and the electric motor, the typewriter and the telephone . . . . And yet this was the very time [at the turn of the twentieth century] when the U.S. Commissioner of Labor took this gloomy view in his official report: “There is no further room in the United States for marked extension of industry, such as occurred during the preceding fifty years.”

New plant for the Cincinnati Milling Machine Co. opened in Oakley in 1911. Cincinnati Museum Center, Cincinnati Historical Society Library
Of course, Geier then reviewed the remarkable array of technological innovations that crowded the period from 1900 to 1950, two-dozen items ranging from air transport to nylon, from frozen foods to tungsten carbide tools. Looking ahead, he voiced a faith in progress without penalties that few today might venture:

When was the door of the future ever so wide open to those who seek progress? Were you and I so bold as to attempt to list the new developments and industries of the future, we would start with nuclear fission. We would note the results of intensive wartime research in developing radar . . . jet propulsion, and the new synthetic rubber industry. We might add textiles of glass . . . titanium and light metal alloys, helicopters, radio telephony, new synthetics and new plastics, television, instrumentatation and remote controls, prefabricated housing, localized weather controls, guided missiles, giant air liners, blind flying [by instruments], synthetic lubricants [which his firm patented], gas turbines and jet engines. And in the production field, we see striking progress in machining and in metallurgy . . .

Indeed, he concluded confidently, “there is every indication that the pace of progress is accelerating.”

Today, as Americans step carefully through the first decade of the twenty-first century, we are surrounded by the achievements, consequences, and aftermaths of the industrialization Geier celebrated in his 1952 address. From the glass and brass lamps sitting on our desks, the electricity that lights them, and the networks of power lying behind every sixty watt bulb, to the extended, complex transportation, communication, and information systems that undergird everyday life, we daily visit and quietly relish the material results of a two hundred year process of transforming nature in order to sustain and shape human societies. Like Geier, most persons involved in animating that process believed it was progressive, truly a good thing. Yet in industrialization’s second century, which we have at last exited, virtues vied with vices as economic and technological innovations first made mass slaughter conceivable, then made it efficient. Similarly, valued innovations delivered collateral and damaging blows to our lands, seas, and air, which we struggle to remedy today.

Overall, if industrialization’s consequences might be fairly regarded as mixed, amid our hopes that the overall balance might eventually be judged as positive, its aftermaths have proved hard all round. The United States may not yet be a post-industrial society, but surely many cities’ and regions’ experience...
of manufacturing now rests far more in the past tense than in the present or future. Fabrication and trade in both basic and advanced products have gone global, as recent job-losses and the debate over “outsourcing” have reminded us. Gone with that globalization are hundreds of thousands of industrial jobs (if not millions—we battle over how to do the numbers). Gone too is the smoky prosperity of factory districts, and well-founded identities of people and places as producers, makers of things. To this day, not far from where I work at Rutgers University in New Jersey, a railroad bridge spanning the Delaware River still proudly boasts in six-foot high letters: “Trenton Makes, the World Takes.” That sign now highlights an ironic aftermath, standing as one element in industrialization’s built environment that is valued these days principally insofar as it can be translated into a magnet for tourism, a part of a broad shift of American sites of production into sites for consumption.

To be sure, the realities of de-industrialization are hard to understand unless we first grasp the earlier, historical dynamics of industrialization. This study will commence by outlining, first, what may be called the “classic” story of industrial development in America. Then it will suggest how recent research, some of it my own, challenges, complicates, and ultimately enriches that tale. Second, this article will examine regional patterns within industrialization, what might be regarded as a national division of labor, and then trace how it shifted across the century from the 1820s to the 1920s. Third, this narrative will sketch three of the large-scale social and economic processes that undergirded industrial development and changed in tandem with the founding of firms and the creation of industrial districts. These processes include the installation of transportation and communication technologies that began tying the nation together, though unevenly; migrations of people with skill and knowledge; and flows of funds and information. Last, we’ll focus specifically on Cincinnati as a case study of industrialization, following its evolution from river town to diversified manufacturing city, from a Porkopolis with thousands of dockside barrels holding salted hog meat to an internationally-recognized center for production of both consumer goods and machinery. This last development, of course, included one of the twentieth century’s most remarkable technologies, aircraft engines—both piston and jet—that Geier mentioned.

Industrialization may be viewed as a dynamic, feedback-intensive project through which humans achieve a gradual, but sustained increase in the ratio of output values to input costs in their appropriations of the material world. This rise in the value added to materials through production is achieved through changes in technology, practice, organization and knowledge, which in turn provoke further experiments in innovation and generate innovation's unintended consequences.

Five quick observations follow from these arguments: First, industrializa-
tion is not just about machines; it's a more inclusive and pervasive project than mechanization. Second, industrialization isn't only about industry as we often imagine it—that is, manufacturing. It also operates in agriculture, fisheries, mining, logging, and perhaps services as well. Third, industrialization should be considered neither logical nor linear. If that were true, success would be simpler and more straightforward. Rather, its course is rich with contingencies, false leads, and unhappy outcomes, rolled out historically alongside triumphs of rising value added and productivity. Fourth, industrialization depends critically on reflexivity, which means that feedback loops from current practice to future prospects are fundamental to its growth and development. In other words, industrialization depends on engineers, designers, managers and workers learning from a success or a failure how to draft fresh initiatives. Moreover, it relies on the creative intersection in practice of its three propulsive elements: technology, organization, and knowledge. Finally, industrialization has long been centered on the production of goods, not services, but it is through industrialization that the service sector takes off. Put another way, expanding services mobilize technologies and knowledge for purposive interactions among individuals and institutions, a trajectory that can only grow and create value in the wake of industrialization. This takes place because, although the products of industry (being inert) are largely indifferent to time and space, services can only happen at specific time-space locations.

In the United States, historians have crafted a “classic” narrative of industrialization that lives on in textbooks, museum exhibitions, and perhaps the History Channel. It goes like this: Once upon a time in the Early Republic, American towns supported a variety of craftsmen who made, well or badly, the material goods a farming society needed, chiefly the goods farm families couldn’t make for themselves. International trade supplied items the craft workers couldn’t produce, or couldn’t produce cheaply and in quantity, at a reasonable level of quality. One such item was woven textiles, especially cotton goods, which we largely purchased from Britain, where industrialization already, by about 1800, sustained large enterprises making cloth in the millions of yards using water- or steam-powered machinery to do so. Americans found these fabrics better made than hand-woven cloth, more durable or more
stylish, and less expensive as well.

Witnessing this, the story goes, a group of Boston merchants determined to reproduce Britain’s success in making textiles, but adapted to New England conditions. One of them toured English mills and made detailed notes on what he saw there: power systems, yarn-spinning machines and fast-running looms. His associates assembled capital reserves, persuaded the government of Massachusetts to grant special charters for their new corporations, and quietly bought land belonging to a failing canal company northwest of Boston. Once a trial factory had worked out well at nearby Waltham, the Boston Associates created Lowell, named for the spy who copied British textile manufacturing technologies. There they augmented the canal’s power yield and constructed a series of massive factories to weave standard fabrics, a machine shop for metal working and machinery construction, rows of brick boardinghouses for the rural women recruited to run looms and spindles, and using their considerable political clout at the national level, arranged for a tariff that erased British price advantages so the Lowell system could get up and running with a nearly guaranteed profit.7

This first American effort at industrialization worked brilliantly, and though it displaced many craftsmen and their trades, it also paved the way for later massive corporate initiatives relying on other new technologies and on standardization—by 1900, in transportation, especially railways spanning the new nation; in communications, telegraph, then telephone and associated electrical equipment; in manufacturing, Pittsburgh’s roaring steelworks and Chicago’s bloody “disassembly lines” in its meatpacking district. Soon, the relentless drive to mass production was crowned by Henry Ford’s moving assembly lines, from which daily emerged acres of identical Model T automobiles. In tandem, great chemical, oil and rubber companies arose on a scale that dwarfed their nineteenth century predecessors. After being staggered by the Great Depression, this entire big business complex rallied to meet the Fascist challenge from Germany and Japan, employing mass production and managerial expertise to win the Second World War, thereby making the United States the globe’s most powerful industrial nation.

This familiar tale sparks pride and patriotism, so what’s the problem here? Two simple difficulties deserve mention. This story line reduces the complexity of industrialization to the trajectories of a small number of ‘leading edge’ enterprises and sectors, bypassing companies and trades where standardization and mass outputs were not the path to profit. It is thus more than incomplete; it is reductionist. Second, the “path to big business” tale is teleological as well—that is, it unfolds as if the purpose of American business activity from 1800 forward were to produce modern corporations dedicated to mass production. When destiny and determinism structure histories, it is likely that a great deal of the past have been shoved aside in order to produce clean story-
lines, in short, that difference and variety have been eliminated in the interest of celebration. Hence, enterprises outside the usual family of big business need to be investigated by historians so we can appreciate their fundamental, strategic roles in generating industrialization.\textsuperscript{8}

One way to get a better sense of how small manufacturers and their products played a role in industrialization, in addition to large corporations and leading edge manufactured goods, is to reflect on how products got made, sold, and used. “Table 1. Product Groups by Uses and Production Formats, 1890-1920” provides an opportunity to do so. It organizes a variety of items produced in the late nineteenth and early twentieth centuries into four formats of production and four user classes.\textsuperscript{9} The user classes include producer durables and non-durables, as well as consumer durables and non-durables. Although consumer goods are an everyday presence, producer goods may not be because these are the items employed by businesses in order to do their work, the “durables” being “hardware” and the non-durables mostly being inputs used up in the work processes. Some categories that may seem unfamiliar are arranged across the top of the table and refer to production strategies: custom, batch, bulk and mass. Some goods

\begin{table}
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\hline
\textbf{Table 1.} & \textbf{Custom} & \textbf{Batch} & \textbf{Bulk} & \textbf{Mass} \\
\hline
\textbf{Producer} & Turbines & Most machinery & Beltling & Standard steel rail \\
\textbf{durables} & Special Machinery & Machine tools & Chain & Typewriters \\
& Conveyors & Pumps & Wire mesh & Telephones \\
& Cast metal patterns & Precision & Pipe, tubing & (leased) \\
\hline
\textbf{Producer} & Cutting tools & Ferrous & Screws, rivets & Fuel oil \\
\textbf{nondur-} & Ship plate & non-ferrous & Staple yarns & Mild steel \\
\textbf{ables} & One-use foundry & alloys & Files & Newsprint \\
& patterns & Special yarns & Wrapping paper & \\
& Linotype and offset & Metal components & Lubricants & \\
& plates & Stationery & & \\
\hline
\textbf{Consumer} & Custom cabinetry, & Home furniture & Door hinges & Household wiring \\
\textbf{durables} & furnishings, jewelry & Carpets & Window glass & \& switches \\
& or carriages & Silverware & Kitchen & “Dollar” watches \\
& Special-order glass & Musical instruments & accessories & \\
& or china & Most china & Linoleum & Sewing machines \\
& & \& glass-\& & & \\
& & ware & & \\
\hline
\end{tabular}
\caption{Product Groups by Uses and Production Formats, 1890-1920.}
\end{table}

in the nineteenth century were ordered by users to fit a specific need; thus they are custom made, one of a kind, like the wedding rings commissioned from a jeweler. Customized goods in Table 1 range from fine furniture or tailored clothing to huge electrical turbines or printing plates for text or illustrations. Other items were made in small or middling sized lots, ten or two hundred at a run, before a firm switched to making other items. Thus textile mills producing cloth for the high fashion market wove a few hundred yards of a design, and then shifted to a different pattern with different colors. Manufacturers called this process dedicated batch production; it’s not small lot manufacturers hoping to become volume producers or seeking the road to mass production. In Table 1 metal components and most machinery have been included in this class, along with carpets and pianos.

In the nineteenth century, custom- and batch-focused enterprises, by meeting clients’ specific demands, could charge much higher prices for their goods than did other producers making goods that ten or even a hundred competitors offered for sale. Thus custom and batch manufacturers generated higher value added per dollar invested, could reap higher per-unit profits, and could pay good wages to the skilled workers without whose knowledge and experience quality production was impossible. Again, these were not failed mass producers, or relics from the craftsman’s era; they constituted a distinctive group of manufacturers devoted to producing specialized products and they made serious money at it. It should be noted too that batch producers were not all “small businesses” either. Some were huge companies, like General Electric, which in the early twentieth century mass-produced light bulbs and fans, but also customized immense power plants and later batch-produced scores of aircraft engine variants.10

Bulk production, unlike batch production, involves making long runs of standardized or staple goods with simple machinery and tools, and this can be done most efficiently with various techniques of mass production. Thus bulk production entails use of integrated and increasingly automatic/interactive technological systems to generate both simple and complex products. Here the difference between sewing work clothing and making light bulbs is important. Many bulk producers operated as small and midsize firms, collectively employing large numbers of workers doing routine tasks, whereas mass producers tended to be legendary big businesses, usually seeking technological and organizational means to speed output and reduce unit costs and workforces.11 Taken together, custom and batch operations constitute “specialty production,” whereas bulk and mass formats represent “routinized production.”

Sketching this inclusive portrait of the industrial landscape has been important for three reasons. First, specialty producers contributed half of America’s value added in manufacturing from the mid-nineteenth century at least into
the 1950s, so an exclusive focus on big-business mass producers ignores half of the industrial economy’s productivity. Second, these specialist manufacturers generated both the goods that made this nation a consumer society in the nineteenth and twentieth centuries, and other goods that underpinned the entire industrialization process—locomotives, ships, machinery and machine tools, alloys, printing presses, fire engines, power plants, plus structural steel and elevators for skyscrapers. Third, industrialization in the United States becomes all the more remarkable in retrospect when it becomes clear that the country developed not just one, but two powerful spheres of production, and that the two were often complementary. Standardized steel and paper, for example, both were fabricated into vast ranges of specialty metal goods, books and magazines, while custom-built machinery produced sheet steel and printing papers by the millions of tons. In fashioning both specialty production and routinized mass production after the mid-nineteenth century, the United States laid the foundation for its twentieth century global economic prominence. Thus, it’s key to recognize that industrialization is more complex and diverse than the standard story allows, and that considering other approaches to manufacturing creates a rich framework for understanding American initiative, creativity and innovation.

In the sprawling process of industrialization, something like a regional division of labor emerged, for industrialization was unevenly distributed across America. By 1900, a great “manufacturing crescent” had developed along a wide curve from central New England southwest through New York City, Trenton, Philadelphia and Baltimore, then west across the mountains to Pittsburgh, Cleveland, Cincinnati, St. Louis, and northwest to Chicago, Milwaukee, and Minneapolis. By contrast, there was next to no southern industrialization, whether in manufacturing, agriculture or the extractive sectors, as slavery and its legacies (low wages, racism, weak financial institutions, underfunded education, and an obsession with defeated traditions) obstructed the in-migration of skilled, immigrant mechanics, of persons possessing engineering and technical knowledge, and of innovative organizations.

Meanwhile, the Great West experienced rural industrialization by the 1880s,
with teams of steam-powered harvesters rolling across bonanza farming's wheat fields, with great pumps and engines animating scattered ore mining camps and smelting operations, and with railroads more sophisticated and reliable than any in the South hauling grain and metals, plus millions of beeves, to midwestern cities and the Pacific coast. At the continent's Pacific edge, the California Gold Rush propelled a narrow but deep stream of manufacturing growth, centered in and around San Francisco. There and to a lesser degree at Seattle, by the 1880s and 1890s, ship building, tool and machinery making, food canning, and printing/publishing accelerated, a dynamic documented by the coast's first technical journal, appropriately titled Industry. As well, within regions, a further pattern of differentiation took shape during the second half of the nineteenth century. In the mid-Atlantic states, for example, a single industrial sector anchored a range of usually midsize cities—steel at Bethlehem, silk at Patterson, woolens in Passaic, chemicals at Wilmington. A second cluster of often larger cities featured several substantial sectors, for example at Baltimore which focused largely on routinized production such as steel, railway goods, and clothing, or in Philadelphia, a nexus for specialty trades, fine metalworking, machinery, technical and scientific instruments, and fashion textiles.

In the Midwest, Cincinnati's printing, furniture, and metalwork sectors echoed the diverse specialty trades evident in Philadelphia. Yet by 1900, like Chicago, Cincinnati had built major capabilities in both bulk and batch manufacturing, commencing with meat processing and brewing/distilling, initially relying on the Ohio River for a transportation corridor that was later supplemented by railways. Moreover, as in various trades at Philadelphia and Chicago, Cincinnati's specialty firms in metalworking concentrated in an industrial district (Mill Creek Valley) which offered a focal point for machinery buyers, in-migrating workers and cross-firm contracting and information trading, thereby generating what economic geographers call "agglomeration effects." Thus at three levels, a spatial division of labor operated in American industrialization—among regions, among cities within regions, and within cities.

Finally, it is important to note three further components that fostered industrialization in the late nineteenth century. All three concern movement, its diffusion and acceleration, a dynamic that is central to industrialization, indeed to capitalism more generally. First, the elaboration of communications and transportation capacities enabled three other flows—of people, information and funds. In the United States, the first significant, innovative communication technology was not the telegraph, but rather the Post Office, which provided fairly reliable mail delivery, and perhaps more important, cheap circulation of newspapers, one of the earliest technologies to distribute information widely. By the 1850s, telegraphy supplanted postal service for urgent busi-
ness communications, though it provided speed at a high price. Around 1900, businesses also began to use newly constructed local, then regional telephone networks. Both transported fresh news quickly, but the telephone allowed real time interaction at a distance, even though developing a reliable inter-regional phone system demanded innovations that took a full generation to develop. Given the Wall Street slogan, “Buy on the rumor, sell on the news,” getting the news as rapidly as possible, and hopefully quicker than one’s rivals, generated critical competitive advantages. Transportation also played an important role in industrialization. Just building railroads, canals, and roads required vast quantities of raw materials, labor, and technologies, far greater than the poles and wires of telegraphy or their successors in telephony. And this effort triggered a massive economic stimulus — cyclical, uneven, and uncertain of profit — but massive nevertheless. As well, transportation moved nineteenth century people and goods both at hitherto unimaginable speeds and to places previously unreachable economically.

As a byproduct of this fashioning of connective webs places were selected propitiously or adversely for future development. Aspiring centers of population and commerce found themselves bypassed by what became the main lines of transportation, as were St. Louis and Cincinnati relative to Cleveland and Chicago, for example. Those places left behind then had to labor mightily to overcome disabilities industrialization had generated.

Communications and transport advances facilitated, but did not guarantee, the migration of people with skills and knowledge to advantaged places. In fact, cultural factors mattered intensely to migrants, as did climate and economic conditions, whether in drawing hardscrabble farming Yankees to western New York and northern Ohio or emigrant Finns and Swedes to Minnesota. For industrializing cities, the flow of information was critical, whether through letters from family members already relocated, through travelers’ and emigrants’ guides in multiple languages, through promotional literature from railroads, cities, and industrial groups, or through newspaper stories in a Hamburg or Milan daily newspaper. By means of such flows of information in the United States and abroad, skilled German and British metalworkers recognized Philadelphia and Cincinnati as excellent destinations, just as less-skilled immigrants understood or soon learned that entry level industrial jobs could readily be found in New York’s garment trades,
the steel mills of Buffalo, Pittsburgh, and Cleveland, or along the railways that connected them.

Capital also followed these pathways of transport and communications, stimulated by information transmissions whose reliability investors had to assess, then as now. Though we often overlook it, relationships involving trust were and are deeply involved in our uses of information, and thus the establishment of trust facilitates our reliance on things learned or told. One of the potential hazards, as nineteenth century transport and communication intensified, thus was the stretching of social networks and a decrease in face-to-face contacts that, earlier in the century, had enabled businessmen to easily assess persons with whom they dealt and the likely reliability of statements and pledges made by potential clients or partners. This had long been a problem in international trade during the age of sail, and was at the time at least in part addressed by establishing the role of “supercargo,” a merchant house’s shipboard representative who accompanied goods from departure to delivery. Economists today, speaking the language of principal-agent dilemmas and moral hazard, acknowledge trust’s continuing importance in conducting business.

Nineteenth century business folks confronted issues of trust and deception through cultural mechanisms, mobilizing the family firm to employ kinsmen or fashioning partnerships with co-religionists, reliable neighbors, or people from the same hometown in Vermont or Ireland. These closely-held allies embodied trust and capital quite literally when they went on the road to sell, buy, or invest. Gradually, in the twentieth century, increasingly abstract systems of expertise and guarantee—insurance, commercial law, professional standards and certifications, warranties, and the like—supplemented and displaced embodied trust, relocating it from persons to contracts and institutions. Unquestionably, this facilitated industrialization in a new age, for no public stock flotation would be feasible without having such mechanisms in place, relied upon by all parties. Yet, as we’ve been again reminded recently, expert systems can be juggled and manipulated to feign reliability, ultimately undermining trust in accounting, corporate earnings statements, profit projections and much else. Unable as a complex society to restore the simplicities (and inherent vulnerabilities) of personalism and embodied knowledge, we have few options other than to
fashion new expert systems to remedy the faults of expert systems that have failed us. This too is a legacy of industrialization.

How did this elaborate capitalist dynamic materialize in and help structure Cincinnati as an industrial city? Key early elements have already been mentioned—the antebellum meatpacking industry, its relation both to users of hog byproducts (fat for candles, skins for leather, etc.) and to the transportation sector that encouraged shipping of goods, shipbuilding, and early machinery construction, especially ships’ engines. Chain migration also helped direct a flood of German laborers into the “Over the Rhine” district, augmented by incomers from Britain and the Mid-Atlantic states, which made possible a multiplication of breweries, metalworking shops, and printers. In a genealogical fashion, metal- and wood-working machinery building descended from the steamboat trades, which faded in postbellum decades, spinning off skilled workers and managers to plant what became anchors for the city’s industrial base—Procter and Gamble, Lodge and Shipley, Fay and Egan, Cincinnati Milling Machine/Milacron and others.20 These parts of the story of Cincinnati’s industrialization have been told and told well. But how did these various elements mesh in the city during the late nineteenth and twentieth centuries to produce what I will call “diversified industrialization?”

To get at the overall movement of economic forces that produced “diversified industrialization” in Cincinnati let us turn to data taken from the United States Manufacturing Census as outlined in “Table 2: Cincinnati: Leading Industrial Sectors, 1880.” The sectors selected for this chart are part of a larger group of fifteen leading manufacturing census categories, each of which represented one percent or more of citywide production value in 1880.21 Together those fifteen sectors accounted for seventy one percent of all production in Cincinnati, but just sixty eight percent of value added, which points to the presence of many small sectors, chiefly mixed or batch production trades.

It should be noted that value added is a crucial indicator when assessing industrialization because it represents the difference between the cost of raw materials and the selling price of goods in the marketplace. For many commodities, like flour or meat, the manufacturing process adds value only modestly; often the price of flour is just ten or fifteen percent above the cost of grain. For specialty goods, however, like machinery or furniture, the cost of metal or wood may account for only a third of the selling price, two thirds
of which represents craft-workers' labor transformed into value. Value added isn't all profit, however. Instead, it represents a pool of funds out of which enterprises pay wages, insurance, rent, repairs, interest, and so forth. The residual from these disbursements is profit. Clearly, assuming the same sales value of goods, those manufacturers making products with much value added will be in a position to allocate more of each sales dollar to wages or to profit than commodity producers who turn out low value added goods. And that in turn provides an incentive for the latter to seek large-scale operations and the economies of scale that standardization brings, so that a ten to fifteen percent value added ratio is calculated on millions in sales, not thousands.

Note thus in Table 2 that the Batch and Mixed\textsuperscript{22} groups had more value added, on a smaller production output, than did the Bulk leaders. Indeed in the Batch sectors, sixty percent of product value was value added in manufacturing, the result of skilled labor and versatile technologies generating diverse metal, wood and printed goods. Note as well the relatively modest number of workers (c. 3,700) in the four Bulk sectors, vs. the much more labor-intensive character of the Mixed and Batch types (22,000+). In "Table 3. Cincinnati: Leading Industrial Sectors, 1880," which contrasts the performance of all fifteen leading sectors in the three groupings,\textsuperscript{23} we see that, as might be expected, the Bulk sectors generated a higher total product value than the other two clusters, had more capital invested (in labor-saving machinery, for example), and supported fewer workers, who nonetheless generated nearly as much total value added as did Mixed and Batch sectors in 1880. By contrast, the proportion of value added to total Product Value in Mixed Sectors is appreciably smaller: forty percent; and the lowest proportion is in Bulk areas: twenty seven percent.

Here it's useful to explore further the fact that Bulk sectors yielded the highest total output with the fewest workers among the three groups. Put more precisely, every Cincinnati bulk sector worker turned out nearly $4,000 in products during 1880, whereas the figure for average batch worker was just over $1,400. Similarly, in terms of capital invested per worker Bulk leads by far, averaging $1,760 invested in machinery and facilities, where Batch

### Table 3

<table>
<thead>
<tr>
<th>Cincinnati: Leading Industrial Sectors, 1880</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capital</td>
</tr>
<tr>
<td>---------</td>
</tr>
<tr>
<td>All Bulk</td>
</tr>
<tr>
<td>All Mixed</td>
</tr>
<tr>
<td>All Batch</td>
</tr>
<tr>
<td>All Leading</td>
</tr>
<tr>
<td>All Sectors</td>
</tr>
</tbody>
</table>

### Table 4

<table>
<thead>
<tr>
<th>Cincinnati: Leading Industrial Sectors, 1900</th>
</tr>
</thead>
<tbody>
<tr>
<td>Workers</td>
</tr>
<tr>
<td>---------</td>
</tr>
<tr>
<td>Bulk-Leather</td>
</tr>
<tr>
<td>Whiskey</td>
</tr>
<tr>
<td>Beer</td>
</tr>
<tr>
<td>Meat prod.</td>
</tr>
<tr>
<td>MClthg. fact.</td>
</tr>
<tr>
<td>Batch- MC, csm</td>
</tr>
<tr>
<td>Women's Ci.</td>
</tr>
<tr>
<td>Metalworking</td>
</tr>
</tbody>
</table>
firms spent just over half as much, $880. As would be the case well into the twentieth century, mass and bulk output factories relied on machinery to simplify labor and reduce costs, yielding routinization. By contrast, batch and custom trades relied on higher paid and higher skilled workforces to address complex problems of specialty production: varied outputs, urgent demand, changing designs and shifting specifications, for example. If we examine value added more closely, each bulk sector worker generated a bit over $1,000 yearly, and each batch worker about $950, a much closer match. As these numbers and the tables more generally suggest, Cincinnati’s industrial economy sustained both approaches in the 1880s, and afterwards, as we will see.

“Table 4. Leading Industrial Sectors, 1900” permits a few quick observations on Cincinnati industry in 1900 in relation to the figures for 1880. First, job availability in the bulk trades, one of 1880’s major sectors, declined as men’s clothing shed nearly 4,000 workers in two decades, though total output remained about the same. Meanwhile, women’s clothing had emerged as a new growth sector, reporting 2,000 workers in 1900 and a fifty percent ratio in value added. Second, the whiskey business became more labor efficient. In fact, in 1900 one-fifth of the number of workers active in 1880 generated twice the value added their predecessors had done twenty years before. (It should be noted that the dollar’s purchasing power was little different at the two dates.) Next, although meat-related work was plainly not an area of expansion in Cincinnati in the late-nineteenth century—reflecting the impact perhaps of Chicago’s massive stockyards’ dominance—metalworking, a batch trade, had taken off in terms of both the size of its workforces and output which went up seventy to eighty percent between 1880 and 1900. During the same period, the value added share of each metalworking product dollar rose from fifty-four cents to fifty-eight cents. This was so because Cincinnati metalworking firms made higher quality and more complex goods that fetched steadily higher prices in relation to the costs of their materials. Indeed, this indicator heralds the advance of the city’s machine tool sectors.

### Table 5
Cincinnati: Leading Sectors, 1900

<table>
<thead>
<tr>
<th></th>
<th>Capital</th>
<th>Workers</th>
<th>Prod Val.</th>
<th>Val. Added</th>
</tr>
</thead>
<tbody>
<tr>
<td>All Bulk</td>
<td>$41.8 mil</td>
<td>20517</td>
<td>$65.6 mil</td>
<td>$22.7 mil</td>
</tr>
<tr>
<td>All Mixed</td>
<td>5.5</td>
<td>2377</td>
<td>7.9</td>
<td>3.0</td>
</tr>
<tr>
<td>All Batch</td>
<td>23.8</td>
<td>16316</td>
<td>29.6</td>
<td>17.8</td>
</tr>
<tr>
<td>All Leading</td>
<td>71.1</td>
<td>39210</td>
<td>103.1</td>
<td>43.5</td>
</tr>
<tr>
<td>All Sectors</td>
<td>107.7</td>
<td>59101</td>
<td>149.2</td>
<td>63.7</td>
</tr>
</tbody>
</table>

In analyzing “Table 5. Cincinnati: Leading Sectors, 1900,” which offers data from the three broad groups of Cincinnati’s turn-of-the-century leading sectors, we find evidence for a broad surge in Cincinnati’s industrialization. In the twenty years from 1880 to 1900, industrial investment more than doubled from $50 million to $108 million and output jumped roughly fifty percent, even as the workforce remained fairly steady in size overall. In part due to a reworking of the Manufacturing Census categories, leading Mixed sectors were fewer,
so part of the growth in other groups’ capital and workers totals arose from this. Even so, each bulk worker generated $3,200 in goods in 1900, a bit less on average than in 1880, but a higher $1,100 in value added. Meanwhile, batch workers, on the same count, produced $1,800 in goods at the century’s turn, thirty percent above their 1880 level, and $1,100 in value added, matching the Bulk trades.

What might this cluster of numbers mean? First, they indicate that both approaches to production prospered in late nineteenth century Cincinnati, with sizable segments of the manufacturing workforce devoted to both routinized and specialty work. As well, no sector dominated the city’s diversified industrial economy, and growth sectors of the economy offset relatively decaying sectors. In other words, if men’s clothing lagged, women’s expanded; as furniture and meatpacking peaked, metalworking and brewing accelerated. Last, the parallel increases in bulk and batch value added per worker (again, with the dollar’s purchasing power about the same at the two dates) point toward rising efficiencies in production either through the purchase and use of new capital equipment, more common in bulk production, or through greater systematization of diverse and flexible production practices on the factory floor, a persistent theme in batch manufacturing.27

For a contrast to patterns of economic development found in the Queen City patterns, consider Cleveland’s leading industrial trades at the turn of the new century as illustrated in “Table 6. Cleveland: Leading Sectors, 1900.”28 Basic iron and steel plus metalworking and bridges here account for 16,000 jobs of the 24,000 represented in the table. In 1900, these same trades also delivered $44 million of the leading sectors’ $68 million in total output. If Cincinnati developed a diversified industrial structure, Cleveland concentrated far more heavily on the metal trades, a focus that in the early decades of the twentieth century would be augmented with the arrival of automobile production. The growing centralization at Detroit of the nation’s car manufacturing industry lead to Cleveland’s emergence as a major supplier of auto-parts to Michigan’s massive assembly plants. By contrast,
Cincinnati retained its structural diversity, as its statistics for 1925 show in "Table 7. Cincinnati: Leading Sectors, 1925."^{29}

In comparing leading sectors in Cincinnati’s economy in 1925 with figures for the same sectors in 1900, it’s clear that Prohibition destroyed the whiskey and beer industries, yet meat products, which seemed to have faltered by 1900, made a substantial comeback. Price inflation for the period from 1900 to 1925 was roughly eighty percent,^{30} but that in no way accounts for the substantial increase in the value of meat output. The sector’s 1900 output of $10.4 million would translate into about $19 million in 1925 prices, not the $40 million shown here. Meat made a comeback, more than doubling output, but not improving its value added ratio that still rested at about fifteen cents per dollar of final products. Men’s clothing made a similar rebound, reaching up toward the 9,000 workers active in 1880, and women’s clothing faded away, dropping below the one percent of production level. So by 1925 Cincinnati did not show a replacement of bulk output by more specialty trades, but rather a continuing balance in its diversification. At the same time, both automobile and electrical sectors grew modestly, but they did not take off as in Cleveland.^{31}

There industrial dedication to metalworking spawned scores of auto components companies, some of which were successors to the nineteenth century wagon and carriage parts makers prevalent in Cleveland.^{32} That noted, Cincinnati’s fine metalworking and machine building firms sustained their growth, producing by 1925 $50 million in goods, almost trebling their 1900 showing (even after taking price inflation into account). The workforce in Cincinnati grew nearly five percent and value added accounted for sixty-two cents of every sales dollar. Finally, in the aggregate portrait summarized in “Table 8. Cincinnati: Leading Sectors, 1925,”^{33} it is clear that Cincinnati industry by that time, with a workforce only a few thousand larger than at the turn of the century, had trebled the value of manufacturing’s output. With inflation accounted for, this manufacturing output value represented a seventy one percent increase over output in 1900 with just seven percent more workers.
Cincinnati's local productivity explosion, in fact, was just a single manifestation of an economic expansion that registered broadly across America as a result of the widespread use of electrical power, increasingly efficient factory designs and fabrication/assembly layouts, more sophisticated accounting, purchasing, and inventory systems, and the like. Yet crucially in Cincinnati, this expansion of output and per-worker productivity was not confined to the bulk and mass production segments of the economy, indeed it was not especially prominent there. In dollars adjusted for inflation, output in leading bulk trades rose just fifteen percent in a quarter century, while product value in batch sectors jumped sixty nine percent. In Cincinnati, there was no replacement of skill-intensive industry by mass production, nor was there a takeover of the industrial landscape by specialist and flexible enterprises. Rather both approaches flourished, making Cincinnati a durable model of diversified industrialization.

In the end, this mix of capabilities carried over quite effectively into the age of aircraft, as Cincinnati's workers proved capable during World War II of generating tens of thousands of mass-produced airplane engines at Curtis-Wright, then in the Cold War thousands of technologically-demanding jet engines, batch-produced in hundreds of different variants at the General Electric Aircraft Engines factory in Evendale. Though this study does not proceed past the 1920s, through the Great Depression, the Second World War and the Cold War (except in its opening passages), it is arguable that Cincinnati's relatively balanced industrial dynamic, in lessening the city-region's dependence on one or a few industrial trades, fostered a manufacturing structure whose diversity made it more durable than the economies of cities reliant on textiles or steel, for example, as their mainstays. Building such a durable structure, and the institutions (civic, commercial, educational) which reinforced and helped reproduce it, proved to be one of Cincinnati's greatest accomplishments, an achievement whose recognition is perhaps overdue.

1. Air Material Command Program, 1952-58, Swan Bergstrom Files, Cincinnati Milacron Papers, Inventory Section Four, Box A1, Cincinnati Historical Society Library, Cincinnati Museum Center, hereafter cited as CHSL.
2. Frederick Geier, "Commencement Address at OMI, 1952," Cincinnati Milacron Papers, Inventory Section Three, F.V. Geier Papers, Box 53a, CHSL.
3. Ibid.
9. Table 1 is adapted from a similar figure printed in Philip Scranton, Endless Novelty: Specialty Production and American Industrialization, 1875-1925 (Princeton: Princeton University Press, 1997), 12.


14. This was in 1888 and the journal was founded by peripatetic machine designer named John Richards, once the “foreman mechanic” for Cincinnati woodworking machinery firm J. A. Fay and Co. See, Scranton, *Endless Novelty*, 27, 34.


22. The Mixed sectors are those in which both a bulk and a batch (or specialty) approach to manufacture co-exist and are not separated in the Census reports. Thus for shoes in Cincinnati, there were both custom shoe/boot makers in small shops and firms that turned out substantial quantities of work shoes for laborers and farmers.

23. Source for Table 3 is the same as for Table 2; see note 21.


26. Source for Table 5 is the same as for Table 4; see note 24.


28. Source for Table 6: *Census Reports: Twelfth Census of the United States*, Volume 8, Part 2, 708-713.


33. Same source as Table 7; see note 29.