1500 1600 1700 1800 1900 2000

THOMAS J. MISA

Leonardo to the INTERNET

Technology and Culture from the Renaissance to the Present

THIRD EDITION

Johns Hopkins University Press
Baltimore

Printed in the United States of America on acid-free paper
9 8 7 6 5 4 3 2 1

Johns Hopkins University Press
2715 North Charles Street
Baltimore, Maryland 21218–4363
www.press.jhu.edu

Library of Congress Cataloging-in-Publication Data

Names: Misa, Thomas J., author.
Title: Leonardo to the internet : technology and culture from the Renaissance to the present / Thomas J. Misa.
Description: Third edition. | Baltimore : Johns Hopkins University Press, 2022. | Series: Johns Hopkins studies in the history of technology | Includes bibliographical references and index.
Identifiers: LCCN 2021018629 | ISBN 9781421443096 (hardcover) | ISBN 9781421443102 (paperback) | ISBN 9781421443119 (ebook)
Subjects: LCSH: Technology—History. | Technology and civilization.
Classification: LCC T15 .M575 2021 | DDC 609—dc23
LC record available at https://lccn.loc.gov/2021018629

A catalog record for this book is available from the British Library.

CHAPTER 6

1900–1950

Materials of Modernism

"The triumphant progress of science makes profound changes in humanity inevitable, changes which are hacking an abyss between those docile slaves of past tradition and us free moderns, who are confident in the radiant splendor of our future."[1] It jars the ear today to hear this raw modernist language, a reminder that the determinist worldview of the modern movement—here voiced in a 1910 manifesto by a group of Italian Futurist painters—is something of a distant memory. Yet in our age of skepticism about science and technology, it is important to appreciate how science and technology helped create a wide swath of modern culture. Modernism in art and architecture during the first half of the twentieth century can be best understood as a wide-ranging aesthetic movement, floated on the deeper currents of social and economic modernization driven by the science-and-systems technologies. Modernism's articulate promoters recognized the rhetorical force and practical effect of linking their vision to these wider socioeconomic changes. We shall see how these promoters took up a stance of "technological fundamentalism," which asserted the desirability and *necessity* of changing society and culture in the name of technology.

Modernists claimed the twentieth century. They selectively praised the builders of classical Greece and Rome and, closer at hand, the Crystal Palace in London, the Eiffel Tower in Paris, a number of massive grain silos and factories across North America, as well as railway carriages, steamships, power stations, and automobiles. Yet, modernists argued, cultural development had failed to keep pace with the new materials and machine forms of the twentieth century. Bruno Taut, a determined booster of steel-and-glass buildings and a leading modern architect himself, condemned the traditional architect's "confused juggling with outward forms and styles" (fig. 6.1). Physically surrounded and artistically suffocated by the monuments of imperial Vienna, Adolf Loos in his polemical *Ornament and Crime* (1908) argued, "the evolution of culture marches with the elimination of ornament from useful objects." Ornament, he wrote, was no longer a valid expression of contemporary culture.[2] An architecture that expressed the new aesthetic possibilities in material form,

FIG. 6.1. FLAT ROOFS AND RIBBON WINDOWS

Bruno Taut's modernist apartment block in Berlin's Neukölln district.

Bruno Taut, *Modern Architecture* (London: The Studio, 1929), 111.

as Taut, Loos, and their fellow modernists advanced the case, would result in better schools, factories, housing, offices, and cities—indeed a better, modern society.

This chapter situates the development of aesthetic modernism in art and architecture in the deeper currents of social, technological, and economic modernization. It first tells a material history of modernism, stressing the influence of new factory-made materials—especially steel and glass—on discourse about what was "modern."[3] It then gives an intellectual and social history of modernism, especially in art and architecture, again centering on modern materials but also contextualizing concepts drawn from abstract art. The account spotlights personal and intellectual interactions among three leading European movements: the Futurists in Italy, de Stijl in the Netherlands, and the Bauhaus in Germany. Finally, the chapter evaluates the often ironic consequences of the modernist movement for building styles, household labor, and the rise of consumer society. Modernism cascaded outward into the world owing to intentional innovations in architectural schools, professional networks, and tireless promotional efforts on behalf of its well-placed practitioners.

MATERIALS FOR MODERNISM

The materials that modernists deemed expressive of the new era—steel, glass, and concrete—were not new. Glass was truly ancient, while concrete dated to Roman times. Steel was a mere 500 years old; for centuries skilled metalworkers in India, the Middle East, and Japan had hammered bars of high-quality steel (called *wootz*, *Damascus*, and *tatara*, respectively) into razor-sharp daggers and fearsome swords. Beginning in the sixteenth century gunmakers in Turkey even coiled and forged Damascus steel bars into gun barrels. Europeans first made homegrown steel in the eighteenth century when the Englishman Benjamin Huntsman perfected his crucible steelmaking process (see chapter 3). Huntsman began with iron bars that he had baked in carbon until their surfaces had absorbed the small, but crucial amount of carbon that gave steel its desirable properties: it was tough, flexible on impact, and able to be hardened when quickly cooled from a high temperature. He then packed these bars—carbon-rich steel on the outside while plain iron inside—into closed clay crucibles, put them into a hot coal-fired oven that melted the metal, and finally cast ingots of steel. Huntsman's crucible steel was used in Sheffield and elsewhere for making cutlery, piano wire, scissors, scientific instruments, and umbrellas, but its high cost limited wider uses. Throughout the early industrial era, textile machines, factory framing, bridges, locomotives, and railroad tracks continued to be made mostly of wrought iron or cast iron.

The first mass-produced steel in the world came from another Englishman, Henry Bessemer. Bessemer, as we related in chapter 3, was a talented London inventor with a string of inventions already to his credit when he turned to iron and steel. A French artillery officer had challenged Bessemer to make a metal that could withstand the explosive force concentrated in a cannon barrel. Cannons could be forged from strips of wrought iron, but the process to make wrought iron required many hours of skilled labor, and their seams sometimes split apart after repeated firings. Cannons were also cast whole from molten brass or cast iron, without seams, but brass was expensive and cast iron, while cheap, had problems of its own. Cast iron was brittle. Since cast-iron cannons might blow open without any warning, gunnery officers hated them. Bessemer set about to remedy this situation. He wanted a metal that was malleable like wrought iron but at low cost. In the 1850s he experimented with several ways of blowing air through liquid iron. If conditions were right, oxygen in the air combined with carbon in the iron, and the resulting combustion made a towering white-hot blast. Again, as with Huntsman's crucibles, the hoped-for result was iron with just enough carbon to make it into steel.

Bessemer's dramatic process slashed the heavy costs to steelmakers for tons of coal and hours of skilled work. For fuel, he simply used the carbon in the iron reacting with air (his 1856 paper claiming "The Manufacture of Malleable Iron and Steel without Fuel" brought laughter from experienced ironmasters), while his patented machinery displaced skilled labor. It turned out that Bessemer's process also could be made large—very large indeed. While his early converting vessel held around 900 pounds of fluid metal, the converters he built in 1858 at his factory in Sheffield's burgeoning steel district held more than ten times as much, 5 tons. In time, 10- and even 25-ton converters were built in England, Germany, and the United States. By comparison makers of crucible steel were limited to batches that could be hoisted out of the melting furnace by hand, around 120 pounds.

The huge volume of Bessemer steel was a boon to large users like the railroads. In the 1870s, nearly 90 percent of all Bessemer steel in the United States was made into rails, and the transcontinental railroads that were built in the next two decades depended heavily on Bessemer steel. But American steelmakers, by focusing so single-mindedly on achieving large *volume* of production with the Bessemer process, failed to achieve satisfactory *quality.* In Chicago, one defective Bessemer beam from the Carnegie mills cracked neatly in two while being delivered by horsecart to the building site. Consequently, structural engineers effectively banned Bessemer steel from skyscrapers and bridges. In the 1890s the railroads themselves experienced dangerous cracks and splits in their Bessemer steel rails.

The successful structural use of steel was a result of European metallurgists' work to improve *quality* rather than maximize output. Finding iron ores with chemical characteristics suitable for the Bessemer process proved a difficult task in Europe. Since the original Bessemer process, which used chemically acid converter linings, could not use the commonly available high-phosphorus iron, European steelmakers developed the Thomas process. It used chemically basic linings in a Bessemer-like converter to rid the steel of the phosphorus that caused it to be brittle. Metallurgists soon found that open-hearth furnaces, too, could be lined with the chemically basic firebricks. This trick allowed steelmakers on both sides of the Atlantic to produce a reliable and cost-effective structural steel. Europeans had the Thomas process. Makers of structural steel in the United States favored open-hearth furnaces. These required from twelve to twenty-four hours to refine a batch of steel, so they were free from the relentless production drive of Bessemer mills, where a blow might take a scant ten minutes. From the 1890s on, architects on both sides of the Atlantic had a practicable structural steel.

Glass is by far the oldest of the "modern" materials. Early glass vases, statues, cups, coins, and jewelry from Egypt and Syria are at least 5,000 years old. Phoenicians and later Romans brought glassmaking to the dominions of their empires, and from the Renaissance onward Venice was renowned as a center for fine glassmaking. By the eighteenth century, Bohemia and Germany had become leading producers of window glass. Glassmaking involved no complicated chemistry and no violent Bessemer blasts but only the careful melting of quartz sand with lead salts to add desired coloring. The manufacture of both steel and glass required extremely high temperatures; it is no coincidence that Bessemer had worked on glass-melting furnaces just prior to his steelmaking experiments. But melting was only the start. Workers making glass needed considerable strength and special skills for pressing or blowing the thick mass of molten material into useful or decorative shapes. Initially, most glass for windows was made by blowing a globe of glass then allowing it to collapse flat on itself. In 1688 French glassmakers began casting and polishing large flat sheets of "plate" glass, up to 84 by 50 inches. By the mid-nineteenth century, the window-glass industry comprised four specialized trades. "Blowers" took iron pipes prepared by "gatherers" and created cylinders of glass (often using brass or iron forms); then "cutters" and "flatteners" split open the newly blown cylinders into flat sheets of window glass.[4]

Glass through most of the nineteenth century was in several ways similar to steel before Bessemer. It was an enormously useful material whose manufacture required much fuel and many hours of skilled labor and whose application was limited by its high cost. Beginning in the 1890s, however, a series of mechanical inventions transformed glassmaking into a highly mechanized, mass production industry. Belgian, English, French, and American glassmakers all took part in this achievement. First, coal-fired pots were replaced by gas-fired continuous-tank melting furnaces; then window-glass making was mechanized along "batch" lines; and finally plate-glass making was made into a wholly continuous process by Henry Ford's automobile engineers. (Broadly similar changes occurred in making glass containers and light bulbs.) By the 1920s the modernists, perhaps even more than they knew, had found in glass a material expressive of their fascination with machine production and continuous flow.

Window glass was mechanized early on. By 1880 Belgian window-glass makers were using so-called tank furnaces fired by artificial gas, and the first American instal-

FIG. 6.2. MASS-PRODUCED WINDOW GLASS

Machine blowing cylinders of glass at Pilkington Brothers' St. Helens works in England. Cylinders were blown up to 40 feet in height before they were detached, cut into lengths, split open, and flattened into huge sheets of window glass.

Raymond McGrath and A. C. Frost, *Glass in Architecture and Decoration* (London: Architectural Press, 1937), 61.

lations of tank furnaces using natural gas soon followed. By 1895 fully 60 percent of American window glass was melted in tank furnaces. Around 1900 a continuous-tank factory in Pennsylvania, with three furnaces, required just seven workers to unload the raw materials, feed them into the hoppers, and stir and prepare the melted glass. Each of the three tank furnaces produced enough glass for ten skilled glass blowers and their numerous helpers, who gathered, blew, flattened, and cut the glass into window sheets. Melting window glass by the batch in pots persisted well into the twentieth century, however. While Pennsylvania accounted for two-fifths of America's total glass production, the discovery of cheap natural gas in Ohio, Indiana, Illinois, and Missouri led to the profusion in these states of small pot-melting furnaces.

The first window-glass blowing machine did not reduce the total number of glassmakers, but did dramatically alter the needed skills. John Lubbers, a window-glass flattener in the employ of the American Window Glass Company—an 1899 merger of firms that accounted for 70 percent of the nation's window-glass capacity and nearly all its tank furnaces—experimented for seven years until 1903 when his batch process was able to compete successfully with handblown window glass. (French, Belgian, and other American inventors had in earlier decades experimented with rival schemes for mechanical blowing.) Lubbers' machine produced huge cylinders of glass, up to twice the diameter and five times as long as the handblown cylinders.

With its clanking and puffing, Lubbers' mechanical monster must have been something to watch (fig. 6.2). It performed a classic batch process. A hollow cast-iron cylinder, the "bait" to "catch" the molten glass, was lowered into a waiting vat of hot glass. After a moment, while glass solidified on the inside of the bait, two motors were started, one to slowly raise the bait with its cylinder of glass attached, and the other blowing air into the growing glass cylinder. When the glass cylinder reached its desired diameter, the blowing motor slowed down while the raising motor kept up its work, pulling out a tall cylinder of glass eventually 35 to 40 feet high. At the top of the cycle, the raising motor was briefly speeded up (to thin out the glass wall), then the huge cylinder of glass was cracked off and swung by crane onto a receiving area. There it was sliced into smaller cylinders, which were split and flattened into window sheets as before. This mechanical contraption required a dozen or more tenders, in addition to the cutters and flatteners. But the new mechanical technology obviously displaced the skilled glass *blowers* and, in the United States at least, wiped out their craft union. By 1905 American window-glass makers had installed 124 of these cylinder machines, and by 1915 a total of 284 cylinder machines (of several different types) accounted for two-thirds of US window-glass production.

A continuous process more streamlined than Lubbers' batch machine helped propel the Libbey-Owens Sheet Glass Company to fame. Development of this process required nearly two decades, beginning with the early experiments of Irving W. Colburn, also working in Pennsylvania, and culminating in its commercial success in 1917, when Libbey built a six-unit factory in Charleston, West Virginia. In the patented Colburn machine, the bait was an iron rod, and it was dipped lengthwise into a shallow pan of hot glass. Once the glass had adhered to the rod, it was pulled by motor up from the vat and over a set of rollers, forming a flat sheet of glass directly. Water-cooled side rollers an inch or two above the molten glass kept the sheet at the proper width. When the sheet extended onto the nearby flattening table, a set of mechanical grip bars took over pulling the ever-lengthening sheet from the vat. From the flattening table the sheet passed directly into an annealing oven, through which it moved on 200 asbestos-covered rollers and was then cut, on a moveable cutting table, into suitable-size sheets. Several of Libbey's competitors imported from Belgium the Fourcault sheet-drawing machine, patented in 1902 but not commercialized until after the First World War. It drew glass straight up into a sheet, rather than horizontally over rollers, and reportedly saved even more labor; only cutters were still needed. Across the 1920s these semi-continuous cylinder and sheet machines together produced an ever-larger share of US window glass. (Handblown window glass dropped from 34 to 2 percent of total production between 1919 and 1926.)

Plate glass was thicker than window glass and could safely be made into much larger sheets. Thick plate glass windows were of crucial importance in the tall office buildings going up in US cities, because ample natural illumination was a primary goal of architects laying out office space in the age of hot, expensive incandescent lights. (American-made plate glass was used mostly for windows; high-quality European plate glass was required for mirrors.) Before 1900 American plate-glass making was wholly dependent on English techniques and machinery. Much labor and skill were required to cast the large plates of glass, weighing up to 1,400 pounds, while semiautomatic machines conducted the subsequent rounds of grinding and polishing to obtain a smooth surface. Industry lore has it that all polishing and grinding machinery was imported from England until an American manufacturer, engaging in a bit of industrial espionage, visited the Pilkington company's plant sometime before 1900 and, upon his return to the States, replicated its secrets.

Plate-glass making between 1900 and 1920 underwent a series of evolutionary changes. Engineers made incremental improvements in processing the varied grades of sand used for grinding and on the rouge used for polishing, while electric motors were increasingly used to drive the huge (35-foot-diameter) round polishing tables. Factory designers sought to speed up the time-intensive grinding and polishing stages. Continuous-flow annealing ovens eased the strains in the newly cast glass. A plate of glass might emerge in as little as three hours from a typical 300-foot-long sequence of five ovens. (By comparison batch-process annealing kilns required forty-eight hours just to cool down so that workmen could climb into the kiln and haul out the sheets by rope.) As a result of these mechanical developments, a large plate of glass that might have taken ten days to complete in 1890 could be finished in as little as thirty-six hours in 1923.

Developments after 1920 transformed plate-glass making into a wholly rather than partially continuous-production industry. In that year, while building his massively integrated River Rouge complex, Henry Ford assigned a team of engineers to work on glassmaking. It seems unclear whether Ford desired simply to raise the volume of production or whether he wanted them to focus on laminated safety glass, a technical challenge that established glassmakers had been unwilling to attempt. In the event, Ford's engineers hit on a continuous production process that became widely adopted by the entire plate-glass industry. In 1927 the Pittsburgh Plate Glass Company, a major manufacturer, owned five plate-glass factories and produced 50 percent of the nation's total, but automobile manufacturers owned eight plate-glass factories (including three of the four continuous-production plants) and their output accounted for 35 percent of the total. By 1929 fully half of American plate glass was manufactured by the continuous process.

In the Ford-style continuous-production scheme, glass flowed from a continuous melting tank (the accepted standard) in a stream onto an inclined plane that formed the glass into a flat sheet. A roller pressed the ever-moving sheet to proper thickness and then the hot glass sheet exited onto a moving table and into a continuous annealing oven. At the far end of the oven, the sheet was cut into desired sizes. Previously, fifty or more workers were needed for the casting stage; now just ten workers tended the entire process, from melting through annealing. Ford engineers also introduced assembly-line principles to the grinding and polishing stages, using a long, narrow continuous conveyer that successively ground and polished each sheet of glass. While the largest plates were still made by the traditional batch regime, the Ford-style continuous-plate process worked best on smaller sizes, and soon these smaller plates were widely used for windows.

The appearance of a pane of glass in 1890 compared with one in 1925 was not so very different. And unit prices for window and plate glass were actually 30–50 percent higher in the mid-1920s than in the 1890s, owing to higher demand. What had changed most was the *amount* of window glass. Window-glass production in the U.S. grew threefold during these years, to 567 million square feet, while plate-glass production grew an astounding fifteenfold, to 148 thousand square feet. Just as with steel, the capability to produce glass in large volumes led to its being "discovered" as a modern material.

MANIFESTOS OF MODERNITY

Modernism in architecture depended on mass-produced modern materials. As early as 1929 the German architect Bruno Taut defined modernism as "flat roofs, huge sheets of glass, 'en tout cas' horizontal ribbon-rows of windows with pillars, which strike the eye as little as may be, by reason of black glass or dull paint, more sheets of concrete than are required for practical purposes, etc."[5] This modern style—as a distinctive architectural style itself—was evident first at the Weissenhof housing exposition at Stuttgart in 1927 and was canonized officially by New York's Museum of Modern Art in 1932. It is recognizable instantly in the glass-box "corporate style" skyscrapers that went up in the 1950s and 1960s, but in the decades since it has become dull and hackneyed from mindless repetition. Central to the development of architectural modernism were the interactions among three groups: the Futurists in Italy, who gave modernism an enthusiastic technology-centered worldview; the members of de Stijl in the Netherlands, who articulated an aesthetic for modern materials; and the synthesis of theory and practice in the Bauhaus in Germany.

The Italian Futurists, a "close-knit fighting unit" led by Filippo Marinetti, found a modern aesthetic in the new world of automobiles, factories, and cities. Marinetti's wild enthusiasm for the machine found expression in a series of culture-defining "manifestos." In the years between 1910 and 1916, the Futurists' poets, painters, sculptors, and architects simply blasted a hole through the traditional views of art and architecture. Two of the group's most creative figures—Umberto Boccioni and Antonio Sant'Elia—were killed in World War I, but across the 1920s Marinetti brought their work to the attention of the embryonic modern movement. The legacies of Futurism include Marinetti's insistence that modern materials were the foundation of modern culture: "I leave you with an explosive gift, this image that best completes our thought: 'Nothing is more beautiful than the steel of a house in construction.'"[6]

Marinetti returned from study in Paris to live and write in the northern Italian city of Milan, at the center of a region undergoing its own second industrial revolution. Textile production around Milan tripled between 1900 and 1912, iron and steel production likewise tripled, to 1,000,000 metric tons, while a world-class automobile industry sprang up in Milan with the establishment of Pirelli and Alfa Romeo and the great FIAT complex in nearby Turin. Automobiles are at the center of Marinetti's founding "Manifesto of Futurism," which launched the modernist vision of technology as a revolutionary cultural force. The 1909 manifesto begins with a set piece at his family's house in old Milan and a late-night discussion among friends. They had argued, he says, to the furthest limits of logic and covered sheets of paper with scrawls. In the middle of the night they felt alone, like proud beacons or forward sentries, curiously at one with "the stokers feeding the hellish fires of great ships . . . the red-hot bellies of locomotives." From the past, they heard the old canal, believed to be a work of Leonardo, "muttering its feeble prayers and the creaking bones of palaces dying above their damp green beards." Then, suddenly, beneath the windows the silence was broken by "the famished roar of automobiles."

Marinetti and his friends piled into three waiting automobiles and raced through the early-morning streets. Swerving around two bicyclists, Marinetti flipped the car and landed in a ditch. Dripping with "good factory muck," he climbed out and proclaimed a manifesto to deliver Italy from "its foul gangrene of professors, archeologists, guides and antiquarians." Marinetti's images, arresting and enduring, forthrightly declared a modern aesthetic in the world of modern technology. "We affirm that the world's splendour has been enriched by a new beauty: the beauty of speed. A racing car whose hood is adorned with great pipes, like serpents of explosive breath—a roaring car that seems to ride on grapeshot—is more beautiful than the *Victory of Samothrace*."

> We will sing of great crowds excited by work, by pleasure, and by revolt; we will sing of the multicolored, polyphonic tides of revolution in the modern capitals; we will sing of the vibrant nightly fervour of arsenals and shipyards blazing with violent electric moons; greedy railway stations that devour smoke-plumed serpents; factories hung on clouds by the crooked lines of their smoke; bridges that leap the rivers like giant gymnasts, flashing in the sun with a glitter of knives; adventurous steamers that sniff the horizon; deep-chested locomotives pawing the tracks like enormous steel horses bridled by tubing; and the sleek flight of planes whose propellers chatter in the wind like banners and seem to cheer like an enthusiastic crowd.

The sculptor Boccioni phrased the cultural shift this way: "The era of the great mechanised individuals has begun, and all the rest is Paleontology."[7]

The first result of Marinetti's call for a techno-cultural revolution was a flurry of free verse with such titles as "L'Elettricità," "A un Aviatore," and "Il Canto della Città di Mannheim." A more significant result came with the paintings of Giacomo Balla and the sculpture of Umberto Boccioni. Their challenge was to deliver on the 1910 manifesto of Futurist painting, which had argued that living art must draw its life from the modern world: "Our forebears drew their artistic inspiration from a religious atmosphere which fed their souls; in the same way we must breathe in the tangible miracles of contemporary life—the iron network of speedy communications which envelops the earth, the transatlantic liners, the dreadnoughts, those marvelous flights which furrow our skies, the profound courage of our submarine navigators . . . the frenetic life of our great cities."[8]

Futurism was not about painting pictures of battleships or airplanes. Balla struggled to express in painting such abstract concepts as dynamism and elasticity, while Boccioni argued that sculptors must "destroy the pretended nobility . . . of bronze and marble" and instead use appropriate combinations of glass, cardboard, cement, iron, electric light, and other modern materials. No classical statues or nude models here. Futurist sculpture, such as Boccioni's *Unique Forms of Continuity in Space* (1913), blended stylized human forms with the machine forms of the modern world. Modern objects, with their "marvelous mathematical and geometrical elements," Boccioni wrote, "will be embedded in the muscular lines of a body. We will see, for example, the wheel of a motor projecting from the armpit of a machinist, or the line of a table cutting through the head of a man who is reading, his book in turn subdividing his stomach with the spread fan of its sharp-edged pages."[9]

With their unbounded enthusiasm for modern technology, the Futurists understandably took a dim view of traditional historical styles. Indeed, in their opinion no proper architecture had existed since the eighteenth century, only the "senseless mixture of the different stylistic elements used to mask the skeletons of modern houses." Their architectural manifesto of 1914 hailed the "new beauty of cement and iron" and called on architects to respond constructively to "the multiplying of machinery, the constantly growing needs imposed by the speed of communications, the concentration of population, hygiene, and a hundred other phenomena of modern life." The Futurist concept of a house would embrace "all the resources of technology and science, generously satisfying all the demands of our habits and our spirit." In short, this would be "an architecture whose sole justification lies in the unique conditions of modern life and its aesthetic correspondence to our sensibilities."

Sant'Elia argued that modern architecture must set tradition aside and make a fresh start: "Modern building materials and scientific concepts are absolutely incompatible with the discipline of historical styles, and are the main reason for the grotesque appearance of 'fashionable' buildings where the architect has tried to use the lightness and superb grace of the iron beam, the fragility of reinforced concrete, to render the heavy curve of the arch and the weight of marble." There was a new ideal of beauty, still emerging yet accessible to the masses. “We feel that we no longer belong to cathedrals, palaces and podiums. We are the men of the great hotels, the railway stations, the wide streets, colossal harbors, covered markets, luminous arcades, straight roads and beneficial demolitions.”[10]

Sant’Elia summed up his ideas about modern materials and urban form in his great city-planning project, the famed Città Nuova. A futuristic vision of a hyperindustrialized Milan, Città Nuova was first exhibited in 1914 and continued to inspire modernist architects for decades. Sant’Elia poured out a flood of modernistic images:

> We must invent and rebuild *ex novo* our Modern city like an immense and tumultuous shipyard, active, mobile and everywhere dynamic, and the modern building like a gigantic machine. Lifts must no longer hide away like solitary worms in the stairwells, but the stairs—now useless—must be abolished, and the lifts must swarm up the façades like serpents of glass and iron. The house of cement, iron, and glass, without carved or painted ornament, rich only in the inherent beauty of its lines and modelling, extraordinarily brutish in its mechanical simplicity, as big as need dictates, and not merely as zoning rules permit, must rise from the brink of a tumultuous abyss; the street which, itself, will no longer lie like a doormat at the level of the thresholds, but plunge storeys deep into the earth, gathering up the traffic of the metropolis connected for necessary transfers to metal cat-walks and high-speed conveyor belts.

We must create the new architecture, Sant’Elia proclaimed, “with strokes of genius, equipped only with a scientific and technological culture.” Sant’Elia (possibly with some help from Marinetti, ever ready with verbal fireworks) finished up with his most widely quoted conclusion: “Things will endure less than us. Every generation must build its own city.”[11]

Marinetti’s provocative avant-garde stance, frank celebration of violence, and crypto-revolutionary polemics landed the Futurists squarely in the middle of postwar fascism. Violence was in the air, and Italy’s liberal democracy was in tatters. More than a dozen groups, ranging from respectable university students to gun-toting street gangs, used *fascio* in their names. As “the new man,” the presumed leader of this motley crew, Marinetti for a time rivaled even Mussolini, known chiefly as the editor of the Socialist Party’s newspaper before the war, and at the time a stridently *anti*-socialist editor and journalist. For Marinetti, perhaps the high point (if one can call it that) came in April 1919, when he took a mob through the streets of Milan and wrecked the headquarters of the Socialist Party's newspaper, an event later known in the regime's legends as "the first victory of Fascism."

Marinetti and Mussolini saw eye-to-eye on war, violence, women, and airplanes but not the established social and moral order. In 1920, Mussolini achieved national political prominence through a newfound alliance with Italy's right-wing business and religious elites; two years later, following the infamous "march on Rome," he was sworn in as the Fascist prime minister of Italy.[12] While Mussolini solidified his grip on national power, Marinetti energetically took up the cause of international Futurism. At home, he signaled his political irreverence by developing a revolution in Italian cooking. His *La Cucina Futurista* features such delicacies as Car Crash—the middle course of a Dynamic Dinner—consisting of "a hemisphere of pressed anchovies joined to a hemisphere of date puree, the whole wrapped up in a large, very thin slice of ham marinated in Marsala." The Aeropoetic Futurist Dinner is set in the cockpit of a Ford Trimotor flying at 3,000 meters. Such dishes as Nocturnal Love Feast and Italian Breasts in the Sunshine express a hedonistic attitude to bodies and sex, which was (grotesquely) theorized in Valentine de Saint-Point's "Futurist Manifesto of Lust" (1913). Pasta was banned in Marinetti's Futurist cuisine.[13]

During the 1920s the Futurists slipped off the stage of Italian politics but became a serious international cultural movement. The best-known Futurist work of architecture was an automobile factory complex built during 1914–26 for the Italian firm FIAT outside Turin. With its high and expansive "daylight" windows, its long and unornamented "planar" walls, and especially its dramatic roof—the site of a high-banked oval track where finished FIAT cars could be test driven—it became a classic modernist icon and a mandatory waypoint on modernist pilgrimages. Marinetti worked tirelessly to bring Futurist concepts and images, especially the several manifestos and Sant'Elia's *Città Nuova*, to receptive audiences. Before the war he proclaimed Futurist manifestos in Paris, London, Rotterdam, and Berlin, while a Futurist exhibition held in Paris subsequently traveled to no fewer than eleven European cities. One receptive audience, as early as 1912, was a group of German Expressionists in Berlin, many of whom were recruited to form the Bauhaus school of design in 1919, as we will see below. A second group that brought Futurist ideas into the larger avant-garde movement was the Dutch movement de Stijl (The Style), which also interacted with the Bauhaus, sharing students and staff.

De Stijl was a loosely interacting group of architects and painters; the name was also the title of their influential art magazine, published from 1917 until 1931.

Sensing in de Stijl a kindred spirit, Marinetti in 1917 sent the Futurist architectural manifesto and a selection of Sant'Elia's drawings to Theo van Doesburg, the group's organizer and central figure. In response *De Stijl* published a warm appreciation ("the perfect management of this building taken as a whole, carried out in modern materials . . . gives this work a freshness, a tautness and definiteness of expression") that secured Sant'Elia's international reputation. *De Stijl*'s far-reaching circulation made one particular drawing, through its multiple reproductions across Europe, the best known of all Sant'Elia's work.[14]

Chief among the de Stijl theorists was Piet Mondrian, a pioneer practitioner of abstract, nonfigurative painting. "The life of today's cultured person turns more and more away from nature; it is an increasingly abstract life," he announced. For de Stijl, the terms *nature* and *abstract* were on opposite sides of the "great divide" between tradition and modernity. Mondrian maintained that artists should recognize that there was an ultimate reality hiding behind everyday appearance and that artists should strive to see through the accidental qualities of surface appearance. He looked to the city as inspiration for the emerging modern style: "The genuinely Modern artist sees the metropolis as Abstract living converted into form; it is nearer to him than nature, and is more likely to stir in him the sense of beauty . . . that is why the metropolis is the place where the coming mathematical artistic temperament is being developed, the place where the new style will emerge." One like-minded modernist put the same point more simply: "After electricity, I lost interest in nature."[15]

Van Doesburg took Mondrian's notions about modern life one step further. In a famous lecture in 1922 called "The Will to Style: The New Form Expression of Life, Art and Technology," van Doesburg told audiences in Jena, Weimar, and Berlin: "Perhaps never before has the struggle between nature and spirit been expressed so clearly as in our time." Machinery, for van Doesburg, was among the progressive forces that promised to lift humans above the primitive state of nature and to foster cultural and spiritual development. The task of the artist was to derive a style—or universal collective manner of expression—that took into account the artistic consequences of modern science and technology:

> Concerning the cultural will to style, the machine comes to the fore. The machine represents the very essence of mental discipline. The attitude towards life and art which is called materialism regarded handiwork as the direct expression of the soul. The new concept of an art of the mind not only postulated the machine as a thing of beauty but also acknowledged

> immediately its endless opportunities for expression in art. A style which no longer aims to create individual paintings, ornaments or private houses but, rather, aims to study through team-work entire quarters of a town, skyscrapers and airports—as the economic situation prescribes—cannot be concerned with handicraft. This can be achieved only with the aid of the machine, because handicraft represents a distinctly individual attitude which contemporary developments have surpassed. Handicraft debased *man* to the status of a machine; the correct use of the machine (to build up a culture) is the only path leading towards the opposite, social liberation.

Iron bridges, locomotives, automobiles, telescopes, airport hangars, funicular railways, and skyscrapers were among the sites van Doesburg identified where the new style was emerging.[16]

A more striking association of technology with a desired cultural change is difficult to imagine. This is the crucial shift: whereas the Futurists sang enthusiastic hymns to modern technology and the dynamic city, for de Stijl modern technology and the city were desirable because they were a *means* by which "to build up a culture." This involved careful decisions ("the correct use of the machine"), not the Futurists' trusting embrace of automobiles or airplanes.

The buildings and theoretical writings of H. P. Berlage heavily influenced members of de Stijl. Architectural "style" in the modern age was for Berlage an elusive quality that an architect achieved by practicing "truth to materials" ("decoration and ornament are quite inessential") and creating spaces with proper geometrical proportions. Berlage's own Amsterdam Stock Exchange became a famous modernist building, but of equal importance was his early grasp and interpretation of Frank Lloyd Wright. Wright was virtually the only American architect noticed by the European modernists. Both Berlage's Stock Exchange (1902) and Wright's Larkin office building (1905) used a combination of brick and advanced structural techniques to create large open-air halls surrounded by galleries, in effect creating open spaces in the very middle of the buildings. Europeans did not learn much from Berlage about Wright's interest in the vernacular and nature worship. Instead, Berlage emphasized Wright's views on the technological inspiration of modern culture ("The machine is the normal tool of our civilization, give it work that it can do well; nothing is of greater importance"). In effect, Berlage selectively quoted Wright to support the technological framing of modernism sought by de Stijl: "The old structural forms, which up to the present time have been called architecture, are decayed. Their life went from them long ago and new conditions industrially, steel and concrete, and terra-cotta in particular, are prophesying a more plastic art." Berlage probably showed Le Corbusier, the prolific writer and influential architectural theorist, a Dutch-designed "modern villa at Bremen" that was Corbusier's first view of a modernist building.[17]

J. J. P. Oud was the leading practicing architect associated with de Stijl. Oud knew Wright's work and appreciated "the clarity of a higher reality" achieved by Sant'Elia, but his own practical experiences grounded his theory. His early work—including several houses, villas, shops, a block of workers' apartments (fig. 6.3), and a modernist vacation home—received such acclaim that in 1918, at the age of twenty-eight, he was named city architect for Rotterdam. In 1921 he wrote *On Modern Architecture and Its Architectonic Possibilities.* Oud clearly sensed and helped articulate the architectural possibilities of modern technology, but at the same time he avoided the quagmire of technological utopianism: "I bow the knee to the wonders of technology, but I do not believe that a liner can be compared to the Parthenon [contra Futurists]. I long for a house that will satisfy my every demand for comfort, but a house is not for me a living-machine [contra Corbusier]." Disappointingly for him, "the art of building . . . acts as a drag on the necessary progress of life," Oud wrote: "the products of technological progress do not find immediate application in building, but are first scrutinized by the standards of the ruling aesthetic, and if, as usual, found to be in opposition to them, will have difficulty in maintaining themselves against the venerable weight of the architectural profession." To help architects embrace the new building materials, he articulated an aesthetic for plate glass, iron and steel, reinforced concrete, and machine-produced components.

> When iron came in, great hopes were entertained of a new architecture, but it fell aesthetically-speaking into the background through improper application. Because of its visible solidity—unlike plate-glass which is only solid to the touch—we have supposed its destination to be the creation of masses and planes, instead of reflecting that the characteristic feature of iron construction is that it offers the maximum of structural strength with the minimum of material. . . . Its architectural value therefore lies in the creation of voids, not solids, in contrast to mass-walling, not continuing it.

Glass at the time was usually employed in small panes joined by glazing bars, so that the window "optically continues the solidity of the wall over the openings as well," but Oud argued that glass should instead be used in the largest possible

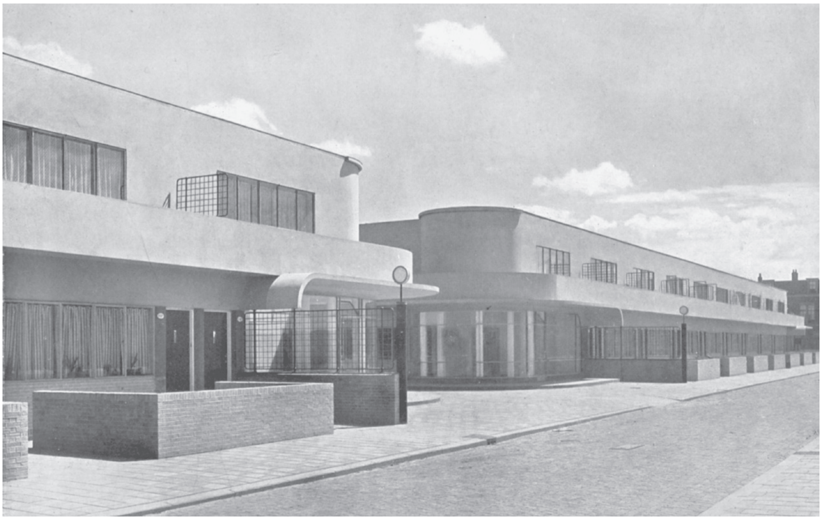

FIG. 6.3. DUTCH MODERNISM BY J. J. P. OUD

"Graceful development in the new tendency . . . modern architecture has definitely won through in Holland," was Bruno Taut's verdict after seeing these workmen's houses at Hook van Holland.

Bruno Taut, *Modern Architecture* (London: The Studio, 1929), 91, 123.

sheet with the smallest possible glazing bars. Reinforced concrete's tensile strength and smooth surface offered the possibility of "extensive horizontal spans and cantilevers" and finished surfaces of "a strict clean line" and "pure homogenous plane." In his conclusion, Oud called for an architecture "rationally based on the circumstances of life today." He also catalogued the proper qualities of modern materials. The new architecture's "ordained task will be, in perfect devotion to an almost impersonal method of technical creation, to shape organisms of clear form and proper proportions. In place of the natural attractions of uncultivated materials . . . it would unfold the stimulating qualities of sophisticated materials, the limpidity of glass, the shine and roundness of finishes, lustrous and shining colors, the glitter of steel, and so forth."[18]

The enduring contribution of de Stijl, then, was not merely to assert, as the Futurists had done, that modern materials had artistic consequences, but to identify specific consequences and embed these in an overarching aesthetic theory. Architects now could associate factory-made building materials like steel, glass, and reinforced concrete with specific architectural forms, such as open spaces, extensive spans, and clean horizontal planes. Moreover, with the suggestion that architects devote themselves to an “impersonal method of technical creation,” Oud took a fateful step by transforming the Futurists’ flexible notion that every generation would have its own architecture into a fixed method of architectural design.

“Picasso, Jacobi, Chaplin, Eiffel, Freud, Stravinsky, Edison etc. all really belong to the Bauhaus,” wrote one of the school’s students in the 1920s. “Bauhaus is a progressive intellectual direction, an attitude of mind that could well be termed a religion.”[19] These heady sentiments found practical expression in an advanced school for art and architecture active in Germany from 1919 to 1933. The Bauhaus was founded and grew during the country’s fitful struggles to sustain democracy and the disastrous hyperinflation of 1921–23. Originally located in the capital city of Weimar, the Bauhaus relocated first to Dessau and finally to Berlin. After its break-up in 1933 its leading figures—Walter Gropius, Mies van der Rohe, Lazlo Moholy-Nagy—emigrated to the United States and took up distinguished teaching careers in Boston and Chicago. Gropius wrote of the Bauhaus, “Its responsibility is to educate men and women to understand the world in which they live, and to invent and create forms symbolizing that world.”[20]

Such a visionary statement might be regarded as yet another wild-eyed manifesto, but by 1919 Gropius was among the progressive German architects, artists, and designers who had substantial experience with industrial design. The Bauhaus began as the fusion of two existing schools, which brought together students of the fine and applied arts. While the fine arts academy’s traditions stretched back into the past, the applied arts school had been organized just fifteen years earlier in a wide-ranging campaign to advance the aesthetic awareness of German industry. Other initiatives of that time included the founding by Hermann Muthesius and Peter Behrens of the Deutscher Werkbund, an association of architects, designers, and industrialists that promoted the gospel of industrial design to German industry, as well as the employment of Behrens by the giant firm AEG (Allgemeine Elektricitäts-Gesellschaft, a successor to German Edison). Behrens was in effect AEG’s in-house style maven. Between 1907 and 1914, several major figures in modern architecture—including Mies van der Rohe, Bruno Taut, Le Corbusier, and Gropius himself—worked in Behrens’ studio. Indeed, many influential modernist buildings can be traced to this Werkbund–Behrens connection, including Behrens’ own factory buildings for AEG (1908–12), Gropius’ Faguswerke (1911–13, fig. 6.4) and Werkbund Pavilion (1914), as well as Taut’s exhibition pavilions for the steel and glass industries (1913–14), which dramatically displayed these modern materials.

The Bauhaus was unusually well positioned to synthesize and transform

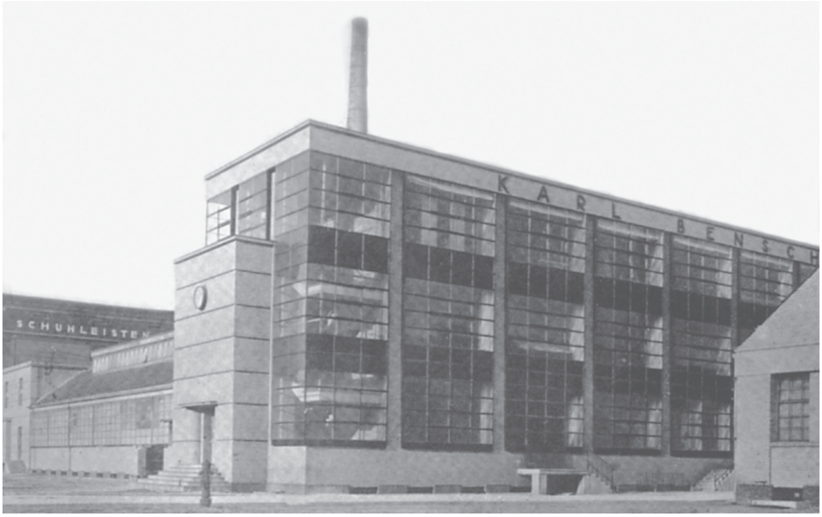

FIG. 6.4. THE FIRST "MODERN" FACTORY

The Faguswerke factory (1911–13), designed by Adolf Meyer and Walter Gropius, made humble shoe lasts for shoemakers, but photographs of the building made history. Modernists praised the glass-enclosed corner stairwell as an open and unbounded vision of space.

Bruno Taut, *Modern Architecture* (London: The Studio, 1929), 57.

advanced concepts circulating in the 1920s about materials, space, and design. Many of its early staff members were drawn from Der Sturm, the Expressionist movement in Berlin that had provided an early audience for the Futurists. These avant-garde painters were especially receptive to the abstract machine-inspired Constructivist art emerging in the early Soviet Union, which the Russian El Lissitzky brought to the attention of Western Europeans through his association with de Stijl in the mid-1920s. Other leading members of de Stijl—including van Doesburg, Mondrian, and Oud—either lectured at the Bauhaus or published in its influential book series. Van Doesburg's lectures at the Bauhaus (including his "Will to Style" quoted earlier) helped turn the Bauhaus away from its early focus on Expressionism, oriental mysticism, and vegetarianism and toward an engagement with real-world problems and advanced artistic concepts.

Elementarism was an abstract concept drafted to the cause. Before the Bauhaus turned it into a distinctive architecture concept, *elementarism* had several diverse meanings. As early as 1915 the Russian abstract painter Kasimir Malevich pointed to the fundamental elements, or simple geometrical forms, that were basic units of his compositions; he later expanded his views in the Bauhaus book *Non-objective World.* In 1917, another exemplar, Gerrit Rietveld, even before he associated with de Stijl, made the first of his famous chairs. They were not intended as comfortable places to sit. Rather, Rietveld separated and analyzed the functions of a chair—sitting, enclosing, supporting—and created a design in which each of the elements of his chairs, made of standard dimensional lumber, was visually separated from the other elements and held in a precise location in space. In 1924, van Doesburg pointed out that "the new architecture is *elementary*," in that it develops from the elements of construction understood in the most comprehensive sense, including function, mass, plane, time, space, light, color, and material. In 1925, self-consciously using the ideas of elementarism, Rietveld built the Schroeder house in Utrecht while van Doesburg coauthored a prize-winning plan for the reconstruction of the central district in Berlin.[21] As interpreted by the Bauhaus theorist Moholy-Nagy, himself an abstract painter, such "elements" were conceived of as the fundamental units of structure and space.

By the mid-1920s students at the Bauhaus were studying with some of the most original artists and architects in Europe. Students began with the six-month introductory course, the Vorkurs and then went on to a three-year formal apprenticeship in a particular craft (e.g., metalwork, pottery, weaving, or woodwork) that resulted in a Journeyman's Diploma. Finally, students could elect a variable period of instruction in architecture or research leading to a Master's Diploma. By 1923 Gropius saw the school as preparing students for modern industry. "The Bauhaus believes the machine to be our modern medium of design and seeks to come to terms with it," he wrote. Training in a craft complemented the desirable "feeling for workmanship" always held by artists and prepared students for designing in mass-production industries.[22] The school's reorientation from mysticism to industry was expressed in its 1923 exposition, Art and Technology—A New Unity.

Von Material zu Architektur, by Lazlo Moholy-Nagy, a key theoretical reflection, was one of the principal Bauhaus texts. In one sense, Moholy-Nagy's title (*From Material to Architecture*) suggests the passage of students from the study of materials, properly theorized, to the study of architecture. This educational plan was expressed in a circular diagram, attributed to Gropius, that showed students passing through the outer layer of the Vorkurs, then specializing in the study of a specific material, and at last taking up the study of architecture, which was at the core. Viewing construction materials as the medium of the modern world figured largely in Moholy-Nagy's career. Moholy-Nagy had come to Berlin in 1921, immersed himself in the avant-garde world of Der Sturm, de Stijl, and Russian abstraction. He was appointed to the Bauhaus in 1923 to oversee the metalworking shop; later in that year he also (with Josef Albers) took on the Vorkurs. One of his innovations was to transform the study of materials from an inspection of their inner nature to an objective physical assessment of their various properties. To test a material's strength or flexibility or workability or transparency, he devised a set of "tactile machines" that were used at the Bauhaus.

IRONIES OF MODERNISM

"We aim to create a clear, organic architecture whose inner logic will be radiant and naked," wrote Walter Gropius in *Idee und Aufbau* (1923). "We want an architecture adapted to our world of machines, radios and fast cars . . . with the increasing strength and solidity of the new materials—steel, concrete, glass—and with the new audacity of engineering, the ponderousness of the old methods of building is giving way to a new lightness and airiness."[23] At the time, Gropius was engaged in creating some modernist icons of his own. He had just completed his striking modernist entry for the Chicago Tribune Tower competition (1922). He would soon turn his architectural energies to designing the new Bauhaus buildings at Dessau (discussed later). The rush to proclaim a distinctive modern Bauhaus style provoked one critic to jest: "Tubular steel chairs: Bauhaus style. Lamp with nickel body and white glass shade: Bauhaus style. Wallpaper covered in cubes: Bauhaus style. Wall without pictures: Bauhaus style. Wall with pictures, no idea what it means: Bauhaus style. Printing with sans serif letters and bold rules: Bauhaus style. doing without capitals: bauhaus style."[24]

The efforts during the 1920s to proclaim a modern style in Germany occurred under unusual difficulties. The country's political turmoil, economic crisis, and street violence made postwar Italy's ferment look calm in comparison. During 1923 the German economy collapsed under the strain of reparations payments imposed on it at the end of World War I. In January 1919 it took eight war-weakened German marks to purchase one US dollar. Four years later it took 7,000 marks, and by December 1923 it would take the stupendous sum of 4.2 trillion marks to purchase one US dollar. In February of that disastrous year, Gropius asked the government for 10 million marks (then equivalent to about $1,000) to help fund the art-and-technology exposition. By the end of that year's hyperinflation, the sum of 10 million marks was worth less than one one-hundred-thousandth of a US penny. The Bauhaus took up the surreal task of designing million-mark banknotes so housewives might buy bread without a wagon to transport the necessary bills. With the stabilization of the German currency in 1924 (the war debts were rescheduled) building projects began once again.

The lack of adequate housing especially plagued Germany's industrial cities, which had grown swiftly during the electricity and chemical booms of the second industrial revolution (see chapter 5). City governments in several parts of Germany began schemes to construct affordable workers' housing. Three cities—Dessau, Berlin, and Frankfurt—gave the German modernists their first opportunities for really large-scale building, and they have figured prominently in histories of modernism ever since. The mayor of industrial Dessau attracted the Bauhaus to his city, offering to fund the salaries of the staff and the construction of new school buildings, in exchange for assistance with his city's housing. For years Gropius had dreamed of rationalizing and industrializing the building process. Not only did he advocate the standardization of component parts, the use of capital-intensive special machinery, and the division of labor; he was also a close student of the labor and organizational methods of Henry Ford and efficiency engineer Frederick W. Taylor. And as we will see, such modernistic "rationalization" came with a similar vengeance to the household and the housewife who worked there.

At Dessau Gropius in effect offered the Bauhaus as an experimental laboratory for the housing industry. His commission from the city was to design and build 316 two-story houses, together with a four-story building for the local cooperative. Like Ford, Gropius specially planned the smooth flow of materials. Composite building blocks and reinforced-concrete beams were fabricated at the building site. The houses stood in rows, and rails laid between them carried in the building materials. Such laborsaving machines as concrete mixers, stone crushers, building-block makers, and reinforced-concrete beam fabricators created a factory-like environment. Like Taylor, Gropius had the planners write out detailed schedules and instructions for the building process. Individual workers performed the same tasks repeatedly on each of the standardized houses.[25]

The housing program in Berlin during the 1920s matched Dessau in innovative construction techniques and use of the modern style, but dwarfed Dessau in scale. To deal with the capital city's housing shortage, Martin Wagner, soon to become Berlin's chief city architect, in 1924 founded a building society, Gemeinnützige Heimstätten-Spar-und-Bau A.G. (GEHAG). Wagner, an engineer and member of the Socialist Party, had previously formed cooperatives of building crafts workers; in turn, trade unions financed GEHAG, soon one of Berlin's two largest building societies. GEHAG's twin aims were to develop economical building techniques and to build low-cost housing. In the five-year period 1925–29, the city's building societies together put up nearly 64,000 dwelling units, and around one-fifth of these were

FIG. 6.5. MAY CONSTRUCTION SYSTEM IN FRANKFURT

In the late 1920s Ernst May, the city architect for Frankfurt, oversaw the building of 15,000 dwelling units there. May's research team devised special construction techniques (e.g., the prefabricated "slabs" of concrete shown here) to hold down costs and speed up the building process. The result was a practical demonstration of mass-produced housing at reasonable cost.

Bruno Taut, *Modern Architecture* (London: Studio, 1929), 114.

designed by modernist architects. (Private enterprise added 37,000 more units.) In preparation for this effort, Wagner visited the United States to examine industrialized building techniques while GEHAG's chief architect, Bruno Taut, studied garden cities in the Netherlands.

Berlin in the mid-1920s was something of a modernist mecca. In 1925 Taut began work on the Britz estate, which would encompass 1,480 GEHAG dwellings, the construction of which employed lifting and earth-moving equipment and rational division of labor. Taut used standardized forms to create a distinctive horseshoe-shaped block. He also designed large estates in the Berlin districts of Wedding, Reinickendorf, and Zehlendorf, the last including 1,600 dwellings in three- and four-story blocks as well as individual houses.[26] Gropius, along with four other architects, built the vast Siemens estate in Berlin for the employees of that electrical firm. These modernist dwellings all featured flat roofs, low rents, communal washhouses, and plenty of light, air, and open space.[27]

But neither Dessau nor Berlin matched the housing campaign of Frankfurt. There, in one of western Germany's largest cities, the building effort rehoused 9 percent of the entire population. Under the energetic direction of Ernst May, the city's official architect, no fewer than 15,174 dwelling units were completed between 1926 and 1930 (fig. 6.5). In 1925 May drew up a ten-year program that called for the city itself to build new housing and for building societies and foundations to do likewise following the city's plans and standards. May did much of the designing himself for the largest estates at the outskirts of the city. (Gropius did a block of 198 flats, while Mart Stam, whom Gropius had once asked to head the Bauhaus architecture effort, completed an 800-flat complex.) May's office established standards for the new building projects; these standards specified the size and placement of doors and windows, ground plans of different sizes, and the famous space-saving kitchens described next. May and his colleagues at the Municipal Building Department carried out research into special building techniques. Cost savings were a paramount concern; by 1927 a factory was turning out precast concrete wall slabs that permitted the walls of a flat to be put up in less than a day and a half. The modern Frankfurt "houses are as much alike as Ford cars," noted one American. "They are all built in units. The large house has more units than the small one, that is all. With the introduction of machine-made houses, the architect becomes an engineer."[28]

A bit south of Frankfurt, at Stuttgart, the emerging modern style had its first highbrow showcase in 1927. Although the city commissioned only sixty dwellings, the Weissenhof housing exposition had immense influence on international modernism. Mies van der Rohe was designated as the director, and he invited fifteen of the best-known modern architects—including Oud and Stam from the Netherlands, Corbusier from Paris, Josef Frank from Vienna, and many of the notable Germans, including Behrens, Poelzig, Taut, and Gropius. The model housing estate coincided with a major Werkbund exhibition and was on public view for an entire year. When the exhibition opened, up to 20,000 people a day saw the new architecture. What is more, May brought numerous exhibition-goers to view his projects in nearby Frankfurt. As Mies put it, the new architecture reflected "the struggle for a new way of habitation, together with a rational use of new materials and new structures."[29]

The Stuttgart exposition of 1927 was the first salvo in a wide-ranging campaign to frame modernism as rational, technological, and progressive. In 1932, the Museum of Modern Art in New York gave top billing to its “International Style” exhibition, which displayed and canonized the preponderantly European works representing this strain of modernist architecture. Later homegrown American contributions to the modern style included world’s fair expositions at Chicago (1933) and New York (1939), especially the General Motors “World of Tomorrow” pavilion, which linked science, rationalization, and progress through technology.[30] The Congrès Internationaux d’Architecture Moderne, known as CIAM (1928–56), with its noisy conferences and its edgy and polemical “charters,” also shaped the contours of the modern style; it did so in such an assertive way that it became known as a kind of international modernist mafia. As mentioned earlier many leading modernists came to the United States after fleeing Hitler, who mandated “authentic German” styles in architecture and brutally suppressed the left-wing social movements that had supported many of the modernists.[31] The influential teaching of Bauhaus exiles Gropius, Moholy-Nagy, and Mies van der Rohe in Boston and Chicago raised a generation of US-trained architects and designers who imbibed the modern movement directly from these masters. In the 1950s, in architecture at least, the International Style, or Modern Movement, became a well-entrenched orthodoxy.

While the public campaign to enshrine modernism in architecture is well known—one cannot overlook the thousands of modernist office buildings, apartments, hospitals, government buildings, and schools built worldwide in the decades since the 1920s as well as the “car friendly” cities that emerged from Stockholm to Los Angeles under the sway of modernist urban planning—an equally influential set of developments brought modernism to the home. Here, modernism’s rationalizing and scientizing impulses interacted with established notions about the household and about women’s roles as homemakers. The “Frankfurt kitchen,” designed in 1926 by Margarete Schütte-Lihotzky (Grete Lihotzky), became a classic and well-regarded modernist icon.

The outlines of Lihotzky’s dramatic life story make her an irresistible heroic figure. Trained in Vienna as an architect, she was one of very few women to thrive in that male-dominated field. She worked energetically to bring workers’ perspectives to her projects for housing, schools, and hospitals in Vienna (1921–25), Frankfurt (1926–29), Moscow (1930–37), and Istanbul (1938–40). Her Frankfurt kitchen became so well known that when chief city architect Ernst May moved to Moscow, she agreed to continue working with him only if she *not* do any more kitchens. (In Moscow, she worked mostly on children’s nurseries, clubs, and schools.) In 1940 she returned to Austria to join the resistance movement fighting fascism, but within weeks she was arrested, narrowly escaped a death sentence, and spent the war in a Bavarian prison. After the war, she helped with the reconstruction of Vienna, was active in CIAM, and kept up her architectural practice, engaging in many international study trips, publications, and projects through the 1970s.[32]

Household reform in Germany during the 1920s, as Lihotzky discovered, was crowded with diverse actors. The national government, while formally committed to equal rights for women and men, enacted a policy of "female redomestication." This policy encouraged young women to embrace traditional women's roles of homemaker, mother, and supporter for her husband. The government hoped to end the "drudgery" of housework and to reconceive it as modern, scientific, and professional. Modernizing housework through the use of Tayloristic "scientific management" principles was precisely the point of Christine Frederick's *The New Housekeeping: Efficiency Studies in Home Management* (published in the United States in 1913, translated into German in 1922 as *Die rationelle Haushaltführung*) and was a central message of Elisabeth Lüders and Erna Meyer, both prolific authors on women's reform issues and advisors to government and industry. In a leading German engineering journal, Meyer wrote that "the household, exactly like the workshop and the factory, must be understood as a manufacturing enterprise."[33]

The German government agency charged with rationalizing workshops and factories also worked closely with several women's groups to rationalize the household. The Federation of German Women's Associations (Bund Deutscher Frauenvereine), with its one million total members, was the country's largest association of women. With the federation's support the national government enacted compulsory home economics courses for girls and sponsored vocational secondary schools where women learned to be "professional" seamstresses, laundresses, and day-care attendants. Within the federation, the conservative Federal Union of German Housewives Associations (Reichverband Deutscher Hausfrauenvereine), originally founded to address the "servant problem," became a formal advisory body with special expertise on housewifery to the Reich Research Organization. The union's effort to modernize housekeeping resulted in numerous conferences, publications, and exhibitions, including one in Berlin in 1928 that featured a set of model kitchens.[34]

Lihotzhy's work on rational kitchen designs, then, emerged in the context of substantial governmental, industrial, and associational interest in the topic. Ernst May himself initiated a research program on "domestic culture" to shape his Frankfurt housing designs. The program's investigations involved psychology, evaluations of

FIG. 6.6. LIHOTZKY'S FRANKFURT KITCHEN.

"This kitchen was not only designed to save time but also to create an attractive room in which it was pleasant to be," wrote Grete Lihotzky of her space-saving kitchen. Her compact design eliminated "unneeded" steps that made a housewife's work inefficient. More than 10,000 of these factory-built kitchen units were installed in Frankfurt's large-scale housing program.

Peter Noever, ed., *Die Frankfurter Küche* (Berlin: Ernst & Sohn, n.d.), 45.

materials and products, and scientific management principles; researchers studied such diverse areas as household products, consumer markets, appliances, and home economics classrooms. May's chosen household products became an officially recommended line and were publicized in his journal, *The New Frankfurt*. The Frankfurt houses aimed at "air, light and sun in every room of the dwellings . . . sufficient bedrooms" for children, and "extensive lightening of the work of the housewife to free her for the education of the children and to take part in the interests of the husband and work in the garden," noted one of May's assistants. Lihotzhy developed her kitchen design using the principles of Frederick Taylor's time-and-motion studies (for example, reducing the "unneeded" steps a housewife made within her kitchen and in taking food to the nearby eating room), as well as giving careful attention to materials.

Lihotzky's kitchen combined diverse colors and an effective design into a compact and photogenic whole (fig. 6.6). (By comparison a contemporaneous kitchen designed by J. J. P. Oud and Erna Meyer for a Weissenhof house appears ugly, spare, and stark.) Summarizing Lihotzky's own description, one can tell that "some man" was not the designer. The gas range featured an enameled surface for easy cleaning and a "cooking box" (*Kochkiste*) where food that had been precooked in the morning could be left to stew all day, saving the working woman time and energy. The flour drawer, made of oak containing tannic acid, kept worms out. Fully illuminated by an ample window, the worktable, made of beech, featured an easily cleaned metal channel for vegetable waste. Cupboards for crockery were enclosed by glass windows and sealed against dust. Other features integrated into the compact plan of 1.9 by 3.44 meters were a fold-down ironing board, an insulated twin sink, a unit above the sink for drying and storing plates, and a moveable electric light. The kitchen fairly bristled with storage drawers. Most extant photographs of Lihotzky's Frankfurt kitchen are black-and-white, so they fail to reveal that Lihotzky featured color: "The combination of ultramarine blue wooden components (flies avoid the colour blue) with light grey–ochre tiles, the aluminum and white-metal parts together with the black, horizontal areas such as the flooring, work surfaces and cooker ensured that this kitchen was not only designed to save time but also to create an attractive room in which it was pleasant to be."[35]

During the peak years of the Frankfurt building campaign in the late 1920s, Lihotzky's kitchen was installed in 10,000 Frankfurt apartments. In fact, she had worked closely with the manufacturer, Georg Grumbach, to achieve an easily manufactured design. Grumbach's company assembled the kitchens as factory-built units and shipped them whole to the construction site, where they were lifted into place by cranes. Her kitchen also went into production in Sweden, after it was extensively praised in a Stockholm exhibition.

Looking at the modernist movement as a whole, then, a rich set of ironies pervades the history of aesthetic modernism and modern materials. While many of the key figures were, at least in the 1920s, activists committed to achieving better housing for workers, modernism in the 1950s became a corporate style associated with avowedly non-socialist IBM, Sears, and a multitude of cash-rich oil and insurance corporations. Modernism as an overarching style professed itself to be a natural and inevitable development, reflecting the necessary logic of modern technological society; and yet the campaign to enthrone modernism was intensely proactive and political: in the 1920s it was furthered by left-wing city housing projects, in the 1930s modernist architects were banned by the National Socialists, and in the 1940s onward into the Cold War years a certain interpretation of aesthetic modernism—with its socialist origins carefully trimmed away—was the object of intense promotional efforts by CIAM, the Museum of Modern Art, and other highbrow tastemakers. Finally, what can we make of Grete Lihotzky, a committed communist, negotiating with a private manufacturer to mass-produce her kitchen designs? (The Grumbach factories also took orders directly from private homeowners who wanted the Frankfurt kitchen.) The Frankfurt housing developments themselves remained too expensive for the working-class families for whom they were designed. Instead, the Frankfurt apartments filled up with families from the middle class and well-paid skilled workers.

Modern designers and architects, motivated by a variety of impulses, actively took up the possibilities of mass-produced machine-age glass and steel. These materials—typically inexpensive, available in large quantities, and factory-manufactured—made it economically possible to dream of building housing for the masses, in a way that was difficult to achieve with hand-cut stone or custom wood construction. The modern materials were also something of a nucleation point for technological fundamentalists asserting the imperative to change society in the name of technology. In examining how "technology changes society" we see that social actors, frequently asserting a technological fundamentalism that resonates deeply, actively work to create aesthetic theories, exemplary artifacts, supportive educational ventures, and broader cultural and political movements that embed their views in the wider society. If these techno-cultural actors fail to achieve their visions, we largely forget them. If they succeed, we believe that technology itself has changed society.