WOULD TROTSKY WEAR A BLUETOOTH?

Technological Utopianism under Socialism, 1917–1989

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Would Trotsky Wear a Bluetooth?

Lipa Grigorevich Rojter (1910–94), "Woman at Work," 1932, xylograph. The joys of socialism enable the female and male labor to stride forward, overcoming all obstacles, on the way to building an urban, industrial future. Courtesy of the Allan Gamborg Gallery, Moscow, Russia.

TRACTORS, STEEL MILLS, CONCRETE, AND OTHER JOYS OF SOCIALISM

Magnificent, ornate subway stations; massive hydroelectric power stations producing copious quantities of electricity; collective farms with fields of grain stretching to the horizon; literacy, public health, and other campaigns that succeeded in a matter of years in increasing the well-being of all citizens; universal medical care and free higher education; and an end to unemployment—these achievements of the socialist nations of the twentieth century astounded many observers in the capitalist democracies because of the scale and speed of these feats. A number of observers worried that other nations around the world might succumb to the allure of communism, its unquestioned economic achievements, rapidly growing industrial output and agriculture harvests, as well as the seeming equality of all people, attendant atheism, collectivist ownership of property, and rejection of the sacrosanct profit motive. Yet the fall of the Berlin Wall in 1989 and the breakup of the Soviet Union in 1991 indicated that the socialist experiment failed to measure up to its promises of equality of men and women and minority nationalities, plentiful goods and services, an end to backbreaking labor, and industrialization without the human and environmental costs that befell England, Germany, and the United States in the nineteenth century.

Socialist leaders were convinced that the performance of technology under socialist circumstances—as Marx would say, with socialist productive relations—would far outdistance that under capitalism. They largely viewed technology as value-neutral, independent of the system in which it was created. Even if capitalist engineers and scientists remained politically suspect, the fruits of their labor—based on understandings and applications of universal laws of nature—could serve either the businessman or the proletarian. Indeed, technology was the main engine of progress. Bolshevik leader Leon Trotsky referred to technology, specifically the tractor, as a "cultural tugboat," capable of bringing the peasant and worker into the modern era. For him, technology was the highest form of culture. Sergei Kirov, the Leningrad Party leader until his assassination in 1934 by order of Joseph Stalin, praised the internal combustion engine as worthy of prayer—and this in a nation of official atheism.

In spite of the centrality of modern technology to the economic successes and political legitimacy of the socialist experiment, and in the views of socialist leaders, we remain at an early stage of appreciation of its place in that history. The socialist economies—the Soviet Union, the countries of East Central Europe, North Korea, China, Cuba, and so on—all were at an early stage of economic development. Within a generation they succeeded, in one way or another, in catapulting themselves into the modern industrial world: in the case of the USSR, copying, importing, mimicking, or stealing advanced technology, often from the United States, Sweden, England, and Germany. The next generation of socialist nations drew heavily on the Soviet experience and sought to foster indigenous innovation and diffusion, with varying success, although alternative approaches were limited by the Red Army military occupation of Eastern Europe.[1]

Because of the cold war, the history of technology under socialism has been skewed toward the consideration of military topics; to the space race, nuclear weapons, and nuclear power; and to issues of industrial development.[2] Some of this focus is understandable given the fact that the leaders of the socialist world incessantly touted rapid growth of heavy industry as the sine qua non of their political, social, educational, and ideological systems. Because of cold war competition between the two world systems, capitalist and socialist, many analysts have sought to prove that their technologies—their space shuttles, their rockets, their reactors, their concrete factories and smelters—were first to space, or largest in the world, or perhaps the most prolific in spitting out cubic meters and tons of ingots, prefabricated concrete forms, lumber, and so on. When scholars have considered engineering education, they have focused largely on

the contribution of technical specialists to increased output and other stratospheric achievements. They have given inadequate attention, therefore, to Marxist philosophy of technology, the attitudes of Marxian leaders toward technology generally and western technology specifically, and they have only indirectly considered the disjunction between the rhetoric of those leaders and the environmental and human costs of the chosen path to technological development. They have adequately investigated neither the worker's relationship toward socialist technology nor how women workers, peasants, and white collar workers were confronted with the paradoxes of socialist technologies of work and home.

Elsewhere I have argued that the essential features of large-scale technological systems held across political-economic systems. American leaders insisted that their hydroelectric power stations, highways, railroads, and mining and smelting operations benefited the worker directly, reflecting democratic politics. Soviet leaders made the same claims. Yet what I called "brute force technologies" required brute force politics in both systems, and the social and environmental costs of technologies prevailed in both democratic-market systems and authoritarian-planned economic systems.[3] In this book I again alert the reader to those features of technology that hold across systems. These include the leaders' assertions that technologies served the masses, demonstrated the system's superiority over other systems, and reflected democracy on the march. Technology in both systems was a symbol of progress and legitimacy.

Of course, in both capitalism and socialism the worker often paid the price for technological "progress" in low wages, poor housing, pollution, and perhaps even debilitating injury or death in the factory. Often, workers had to give up what was familiar and leave their homes in search of work, or they were forcibly moved to facilitate technology's advance in a new road, railroad, or dam. Even more surprising, efforts to free technological development from unnecessary regulations led officials in several U.S. administrations to adopt policies strikingly similar to their authoritarian counterparts—postponing, weakening, or disregarding laws pertaining to worker safety and pollution control, redefining such ecosystems as wetlands, and so on—that put workers and the environment at risk.

Of greater importance to this book is how socialist technology differed from capitalist: what is socialist about socialist technology? My concern here is how the leaders of the socialist governments in Eastern Europe, the USSR, and North Korea failed to live up to their claims and rhetoric to create socialist societies of technological plenty and ease of labor, in which workers, peasants,

and managers alike engaged the production process in farm and factory with joy, and in which metaphorical sunshine prevailed rather than smoke and din. For a series of reasons, the technologies of socialism did not liberate the worker, and in fact the worker lived in greater squalor than his capitalist working brothers and sisters, in closer proximity to dangerous, highly polluting factories, and often without the right even to engage in job actions. First, technologies reflect relations of knowledge and power, so that the import, purchase, or theft of advanced western technology, in particular American and European technology, led to the import of unequal relations between worker and manager in socialism. Second, the socialist nations attempted to reach and surpass the technological West in one generation from largely poor agrarian to industrial societies. This led to investment decisions emphasizing industry over labor and heavy industry over light industry. Third, fearing imminent attack from fascist or other capitalist regimes, socialist leaders insisted on industrial development at all costs, ignoring investment in housing, schools, public health, and other sectors of the economy. Fourth, perhaps more than in other systems, socialist leaders saw large-scale technologies as symbols of their legitimacy that must be built by armies of laborers in short order. As a result (as the chapters in this book explore), they ignored worker safety; saw greater value in big dams, nuclear reactors, subways, and metallurgical factories than in housing and consumer goods ("concrete" not "kimchi"); and liberated women to work in factories but not from traditional family roles. They threw together dozens of smoke-belching factories that have destroyed the natural environment, leading to the creation of "industrial deserts." Further, in developing client states, the USSR exerted a tremendous influence on the technological style adopted in other countries that often rivaled indigenous traditions and engineering practices.

I use the word *socialist* because, in spite of their claims, no socialist society achieved fully the essential features of communism, including a classless society and an end to alienation of the worker from the machine. Indeed, Nikita Khrushchev caused his successors great embarrassment by promising to achieve communism by 1980 in the Third Party Program passed under his chairmanship at the Twenty-Second Party Congress in 1961. Feeling embarrassment over the realization that the USSR would not come close to the 1980 target, Leonid Brezhnev nevertheless proudly defined another stage of economic development on the road to communism: "developed socialism." This engendered the Soviet joke that yet one more stage awaited on the way to the glorious communist future: alcoholism.

In these essays I intend to begin a conversation to consider what was *socialist* about socialist technology and, in comparison with the technological experience in the West, primarily that of the United States, to determine what we can learn about the always crucial issues of safety, efficiency, justice, gender, environmental degradation, and so on, that are intimately tied to the development and diffusion of any technology but have surely been overlooked by analysts of the socialist experience. Socialist leaders and engineers recognized that technology has politics. They used technology as a tool of state power and legitimacy in their headlong pursuit of industrial growth and military might. During the cold war, spokespeople of the capitalist and socialist worlds insisted that their technologies were the best, fastest, and most efficient; that they benefited all citizens; and, in rhetoric if not in reality, that they demonstrated the ideological superiority and legitimacy of those regimes. Yet socialist leaders did not fully recognize—or publicly admit—that the paths they chose to achieve high output or to record great tonnages required a subservient relationship of the citizen to their plans and technologies. The socialist leader, engineer, and manager claimed equality of all citizens before technology, and they insisted that the worker would relish labor in clean, well-illuminated, and safe facilities. They believed that liberation of women from exploitation and patriarchal institutions would also accompany the diffusion of socialist technology. But the exhausting and dangerous experience of the worker in the factory, the deadening experience of the housewife/laborer at work and at home, and the subjugation of indigenous peoples to an inflexible ideology of modernization based on the unhesitating embrace of technology revealed quite another politics. In this book I investigate the rhetoric and reality of socialist technology in a series of settings and decades to evaluate the human and environmental costs of the technological experience.

The Russian Revolution and Technological Culture

Marxist philosophers, theorists, and leaders generally held a determinist view of modern technology as the engine of social progress and of its inevitable advance as the key to the transition from capitalism to socialism. Vladimir Lenin and Leon Trotsky saw technology as a panacea for the unfolding socialist society.[4] Surprisingly, Lenin, Trotsky, Kim Il Sung, and other communist leaders shared the views of their American counterparts about the place of technology in modern society. It was, perhaps tautologically, an engine of modernization that enabled rapid transformation of agrarian societies into industrial powerhouses. It

freed workers from arduous labor. Rather than the smoke-belching, dark, and dangerous factories that existed under capitalism, well-illuminated, spacious, well-ventilated, and safe factories would arise under socialism. Crucial to the building of the socialist factory was the production of copious amounts of electricity; electricity would power agriculture and forestry as well. Other Marxist scholars stressed the apolitical nature of technology; the same technology that alienated workers in capitalism would liberate them in socialism. The productive relations, not productive forces, were the crucial factor. Did Marx and Engels share this enthusiasm for technology?

Marx and Engels argued in many places in their voluminous writings that the development of the productive forces—the means of production, tools, implements, machinery and equipment, and "technology" generally—drives the development of society. Adopting a seemingly technologically determinist argument, they put great store in socialism arising inevitably from capitalism when the productive forces have reached a given level of development. G. A. Cohen argues that Marxism is economically determinist, with the economy the driving force of history.[5] Donald MacKenzie has taken exception with this view, concluding through a careful reading of *The German Ideology*, *Capital*, *Grundrisse*, and other works that relations of production can and do hold back the forces of production; people do matter in history. Further, according to MacKenzie, Marx argues that capitalism arises not from changes in technology, but from changes in social relations, for example, in the emergence of a class of propertyless laborers. MacKenzie notes that the technological form of labor of mill workers (the mill) had not changed; the fact that they did not own it had changed their relationship to the technology.[6] A number of Marxist scholars eventually voiced critical evaluations of the place of technology in modern society. For example, Herbert Marcuse argued that technology was a potential tool not only of liberation but of enslavement in both capitalist and socialist systems that tended toward convergence.[7] But while MacKenzie effectively demonstrates that Marx did not argue that "machines drive history," one can argue that, according to Marx, technological change impels social change, and that transformation of the material basis of society is crucial to the socialist future. More important Soviet writers sanguinely asserted that machines *do* drive history. They expected to drive on tractors and other machines powered by electricity off into the socialist sunset.

Most Soviet leaders and political theorists never explicitly addressed technology from a philosophical, social, or political standpoint. We may infer from

some of their pronouncements that many of them believed that technology was the highest form of modern culture, and that engineers and specialists would contribute centrally to the construction of the socialist future. Accordingly, they recognized that America, with its assembly lines and mass production of so many different goods and services, and with its high degree of standardization of processes, possessed precisely this highest technological culture. Certainly Lenin, Trotsky, and a number of other leaders had no problem borrowing from the West, let alone stating the obvious: that the USSR lagged behind Europe and America in technology. What remained was to acquire that technology, through importation, copying and reverse engineering, turnkey agreements, espionage, and theft. In the Soviet period, leaders and engineers fetishized standards and mass production, with five or six basic designs serving most apartments and other construction. They created a unitary system where, for example, only two factories, Elektrosila and the Kharkiv Turbine Works, produced virtually all of the large turbogenerators for the entire empire, another three all of the tractors, and even one, Atommash, was designed to mass-produce eight pressure vessels and associated equipment for 1,000 megawatt (MW) electric reactors annually à la Henry Ford. There would be no wasteful competition or foolish duplication of effort.

The followers of Stalin had a more narrow view of technology and its masters. Socialist leaders grew to fear not only those bourgeois experts on whom they relied to ignite the engine of socialism, but ultimately those engineers who were entirely trained within the socialist system. They orchestrated show trials to punish engineers for alleged "wrecking" and sabotage of projects. They arrested and shot many of them. They worried about the technocratic impulse that had given rise to such phenomena as America, Incorporated, in the United States in the 1930s.[8] Still, they recognized the need to industrialize rapidly on the basis of the world's most modern technology. They established educational and research institutes to foster indigenous innovation, but they created so many planning, bureaucratic, and other obstacles to innovation that they often had to import critical technologies from the West or to reverse-engineer many systems, from airplanes to computers, with the result of a built-in and persistent lag.[9] Because of the fear of financial, professional, or even criminal punishments, engineers were often afraid to push innovations with long-term promise if they meant short-term failures to meet output targets, and this hesitation led in a number of cases to rudimentary designs and inadequate consideration of safety or pollution features.

Marxist revolutions succeeded in agrarian economies, not industrial economies as Marx and Engels had anticipated. This had an impact on Soviet technological style by often requiring socialist engineers to play catch-up. Lenin asserted in *The Development of Capitalism in Russia* (1895) that Tsarist Russia had achieved the capitalist stage, a working class had formed, class struggle between the bourgeoisie and proletariat had intensified, and the nation was ripe for revolution. Yet many fellow Marxists disagreed with Lenin. Marx and Engels anticipated revolutions in industrial economies of plenty, not agrarian economies of want, where it would be an easier matter to create the workers' paradise. Many Russian Marxists, most importantly the Bolsheviks' major prerevolutionary rival, the Mensheviks, argued that it was premature to seize power and attempt to build socialism given the poorly developed industry and infrastructure, the relatively small and certainly unskilled workforce, and the fact that the vast majority of citizens were illiterate peasants who eked out existence with traditional hand tools.

Modern science and technology, which were central features of industry and agriculture in such countries as Germany, England, France, and the United States, had had only a minor impact on the Tsarist economy. Russian industry to a great extent relied on technology transfer from Europe and still largely produced raw materials while importing finished goods. The backwardness of Russia's military, transportation, and other sectors became fully noticeable during World War I. As for agriculture, no such thing as land-grant universities or systematic research existed. In country after country where Marxian revolutions succeeded, this lag in science, technology, and industrial development handicapped the attempt to build societies of plenty. The efforts to build modern industry; collectivize agriculture; fight off perceived internal and external enemies; establish social welfare nets, universal literacy, and education; and redistribute wealth fell short in so many ways. Granted, the USSR industrialized rapidly under Stalin, achieving in a few decades what may have taken longer in Europe. In spite of such achievements as production of iron and concrete, and later of *Sputnik* and tokamak fusion reactors, the workers remained poor, often lived in overcrowded and foul-smelling communal apartments if they had housing at all, and stood in lines for basic goods and services.

A number of leading liberal and leftist members of the Russian intelligentsia worried about the "backwardness" of the masses. By backwardness they meant the entire worldview of the peasant, his superstition and orthodox religious beliefs that made him resistant to change, his poverty, his lack of education, and

other impediments to improving agricultural production and extending the market from local to national and international arenas. They believed that modern, western science was a major tool in the struggle with backwardness. The playwright Maxim Gorky joined with the agronomist Klement Timiriazev in 1916 to form a mouthful of an organization, the Free Association for the Development and Dissemination of the Positive Sciences (known by its Russian acronym, SARRPN), with the stated purposes of overcoming the *muzhik*'s (peasant or, better still, country bumpkin) narrow worldview and making him a citizen in a world of unlimited horizons.[10] In East Central Europe and North Korea communist leaders encountered similar challenges of economic lag and conservative resistance among peasants.

Because of the lag in technological acumen among the masses, the Bolshevik state became the prime mover behind the deployment of the machine and the factory, with the resulting technological style that placed the machine above citizen and had a decidedly negative impact on nature and worker alike. This attitude and impact spread inexorably from Moscow and Leningrad to Warsaw and Nowa Huta, Poland; Sofia and Dimitrovgrad, Bulgaria; Budapest and Sztalinvaros, Hungary; Pyongyang, North Korea; and beyond. The central role of the state in technological development persists in post-Soviet Russia in the space and nuclear power programs. Technologies designed and imposed impatiently without citizen input worked with brute force, not efficiency, leaving behind huge, hulking factories, open pit mines, clear-cut forests, polluted rivers and streams, filthy air, and hazardous waste. The worker—both the male and female worker—was supposed to be the beneficiary of socialist technology but remained the exploited afterthought.

One can make a strong case for overriding similarities in the embrace of modern technology in the capitalist and socialist states of the twentieth century. In both systems state power was crucial to the processes of research, development, innovation, and diffusion. In both, large-scale approaches predominated in most sectors of the economy, from transport to energy, from mining to metallurgy, from food production to education. Engineers and scientists, as products of the Enlightenment, viewed nature with a longing to improve it for the benefit of humankind, and they did not lack modesty about their ability to do so, what I have described as "technological hubris" elsewhere. Many of them see technology as a panacea for the various ailments of society: poverty, scarcity, hunger, illiteracy, poor health, and so on. Drawing on the history of a variety of technologies in the socialist world, I investigate these utopian aspects of modern

technology, how socialist leaders ran smack into the realities of nations that lagged far behind their European and North American counterparts, how overriding political considerations deflected them from goals of using technology to benefit citizens equally, and yet the tremendous accomplishments of socialist states from East Central Europe to the USSR to Korea in transforming economic, educational, and social institutions literally overnight. In some cases, I offer implicit and occasionally explicit comparisons with the capitalist world.

Another question is to what extent technological choices facilitated or handicapped the efforts of socialist leaders, planners, and engineers to build socialism. Given that most of them believed that technology was value-neutral, a tool of great promise that might be abused (in capitalism) or used for the benefit of man and woman (under socialism), they believed it paramount to borrow technology liberally from the West, in particular from the United States and the European industrial powers, for application in hydroelectricity, metallurgy, transport, agriculture—virtually everywhere. They reveled in Fordism and Taylorism to increase production and productivity of labor. When they imported western technology, did they also import such constraints as labor-management disputes, problems in the training of personnel, problems in the effective operation of machinery and equipment, and so on? And, in developing "socialist technology"—what *was* socialist technology?—in what ways was it distinct from capitalist technology, if at all? The breakup of the USSR and the fall of the wall across Eastern Europe permit consideration of these and other questions, given the ability to engage in extensive field research, gain access to archives that were closed, and visit libraries and local and regional museums, all to get a better understanding of the social, political, and cultural contexts for technology. Recently, the leaders of North Korea have also permitted greater access to the nation, although it remains largely a closed society.

In the following chapters I explore the place of technology under socialism as a symbol, an engine of progress, and an all-too-real force of political, economic, and cultural change. I highlight the utopian aspects of the quest for modern technology to solve economic and social challenges that faced such nations as the Soviet Union, the People's Republic of North Korea, and the newly socialist countries of East Central Europe in the postwar world. I evaluate the technological experience in the USSR, Eastern Europe, and North Korea according to the rhetoric of socialist leaders, not according to some arbitrary, universal standard, nor in order to prove that capitalism is a better system, yet implicitly and explicitly in comparisons with the technological experience in the

United States, in large part because those nations often measured their success in relation to the United States. Leon Trotsky certainly measured Soviet achievements against those of the United States. He saw uses for the most modern technology of his day—the airplane, the radio, the railroad, and especially the assembly line—as a panacea for Soviet backwardness. He used the printing press and the locomotive to secure victory as he rushed from breach to breach during the civil war as Commissariat of War and organizer of the Red Army.

Did modern technology liberate the socialist worker? Did the quality of life improve? Did the worker not gain universal health care, overcome illiteracy, abandon superstition, and become a citizen in civic society? Did a new ruling class form with new beneficiaries and new sufferers? Were local peoples and indigenous peoples and peasants forced to conform to new ways of life? Furthermore, weren't the social, environmental, and cultural costs of the headlong push to modernize as great as those under capitalism? If this was the case, what does this tell us about the power of technology to shape our lives?

Shockingly, the socialist states failed to live up to the rhetoric of their claims that technology serves the masses in ways that are more complete and better than in capitalist systems. Rather, the socialist citizen endured a lower quality of life or standard of living, less attention to worker health and safety, and inadequate concern about housing, the environment, and health care. In chapter 1 I answer the rhetorical question about whether Trotsky would wear a Bluetooth. Yes, Trotsky believed that the embrace of advanced technology was the path to communism. It would raise industrial production, overcome the abyss between city and countryside, and promote a modern worldview among the peasantry. Trotsky's writings remain largely ignored because of the successful effort by Stalin to excise him from Soviet history. But an examination of his views reveals that Trotsky was not alone in recognizing how far the country lagged behind the West. Yet if other leaders shared this view, they achieved no consensus as to what steps to take to overcome the lag. During the Stalin era, if the Bolsheviks worried about the lag and insisted on making it up within a few short years, they also adopted autarkic economic relations that handicapped the effort to industrialize rapidly.

Millions of Ukrainian peasants perished during the collectivization campaign. Millions of others perished in gulag labor camps intended to provide cheap labor for road construction, forestry enterprises, and mining and smelting operations. Although the human and environmental costs of industrialization and collectivization were undoubted, Soviet leaders insisted that the East European client states follow the same paths. The similarities concerning rapid in-

dustrialization in Poland, Hungary, Bulgaria, and other countries extended to technology—machinery, equipment, factory organization, urban planning, and so on—everywhere, but especially in newly built "hero" or "production" cities dedicated initially to Stalin (chapter 2). As a consequence, political choices, resource constraints, and fascination with mass production conspired to create a landscape eerily recognizable to anyone who has visited socialist spaces in Hungary, Bulgaria, Romania, Poland, or Eastern Germany, even fifteen years after the fall of communism. A kind of grayness of life prevailed east of the Elbe River because of the "proletarian aesthetics" of the technologies of life and work. Grayness extended to modern nuclear technologies as well.

Stalin's legacy spread far beyond the borders of the USSR to technologies and countries into the twenty-first century, particularly on the Korean Peninsula (chapter 3). Great Leader Kim Il Sung embraced large-scale technological systems for the Democratic People's Republic of Korea that reflected the Stalinist emphasis on heavy industry, massive scale, and collectivized agriculture. This emphasis resulted in depravations that rival Stalin's depravations of the Ukrainian peasant in the 1930s. Rather than provide good, inexpensive housing or adequate food, Great Leader emphasized the need for independence from all economic entanglements. This required tremendous self-sacrifice in housing, health care, transportation, and food. Metaphorically, the citizen had to give up kimchi, the hot pickled vegetable delicacy of Korean culture, for concrete structures.

A surprising continuity exists in socialist technologies in Russia in the twenty-first century. For a variety of reasons, the Russian nuclear ministry, RosAtom, is striving to rejuvenate the nuclear industry that stagnated after the Chernobyl disaster. The reasons include a geographical disjunction between fossil fuel resources, mostly in Siberia and the Far North, and population and industrial centers, mostly in European Russia, and a desire for continued status as a nuclear power among Russian leaders. Indeed, nuclear technology is one of the few technologies that Russia can sell on international markets, and it is a major actor in the development of the Iranian civilian nuclear power industry. Even more, Russian engineers maintain Soviet-era hubris about the promise of nuclear power. The design and construction of floating nuclear power stations, with the promise of sales to Morocco, Namibia, and elsewhere, suggest great continuity with the Soviet past, while greater openness in dealing with nuclear safety indicates changes in practices and attitudes. As a comparison with the nuclear industry in the United States shows, however, in order to be viable, engineers must

address openly and honestly the problem of waste disposal (a sixty-year-old problem); the need to site reactors far from population centers for safety; and the true costs of construction, operation, and transmission. Without a strong state and government subsidies, nuclear power may simply not be economically viable (chapter 4).

Nuclear power was only one of the major contributors to a dreadful legacy of pollution and hazardous waste. The legacy of socialist technology is most obvious in its environmental impact, especially in metallurgical and mining operations. From Eisenhüttenstadt in Eastern Germany to Pyongyang, from Murmansk and Severomorsk on the Arctic Sea to the Aral Sea of Central Asia, the socialist worker toiled not in the glorious garden of plenty but amid dumps of radioactive waste, heavy metals, and petrochemicals, not in field rows of grain, but in erosion. The engineers who brought about this situation had a variety of fields of expertise—including pipe fitting. They carried out a self-proclaimed war on nature to force it to operate according to plan. The result was industrial deserts—vast regions devoid of much vegetation yet home to millions of people—in such regions as the Ural Mountains, whose industrial development is the focus of chapter 5.

Chapter 6, on historical, cultural, and psychological aspects of worker safety and risk in Soviet society, asks why the metaphorical hard hat found no role in socialist industry. The Stalinist emphasis on industrial production ensured that the workplace, the public sphere, and the home would all permit risky practices and behaviors not tolerated in other systems. Both manager and worker came to see accidents as unavoidable, if unfortunate. Their fatalism contributed to an epidemic of injuries and to their indifference toward the frequency. Perhaps no one seriously believed that greater safety would result from greater "discipline" in the face of crippling machines and exhortations to stop drinking. The call for discipline reflected an effort always to blame the worker, not the machine, while drink made monotonous and dangerous work occasionally bearable.

And what of the female worker, the female collective farm laborer, the housewife whose responsibility it was to get the drunken man off the sofa and out the door to work, to dress the children and get them to school, and to provide a communist upbringing on the way to raising pliant, devoted citizens? What of the dual role of the socialist woman to maintain the home and hold down a second full-time job? I am a novice on questions of technology and gender, but I have tried in the last chapter of this book to engage the reader on the paradoxes of socialist liberation, pro-natalist policies, and technology in Stalinist Russia.

In violent worker demonstrations in East Germany in 1953, in revolutions of 1956 in Hungary and Poland and in the Prague Spring of 1968, and in a series of lesser known uprisings in the USSR, many workers and socialist intellectuals sought the establishment of "socialism with a human face." They wished to build socialist society on the foundation of modern technology. They believed that true equality of all peoples, and of men and women, would arise on this foundation. Perhaps their goals were utopian, as were their views of the way technology would liberate them from poverty and want, darkness and cold, even despotism and control. The lesson of these chapters is that public involvement in decisions about investment of scarce resources may be the only path to the creation of technologies with a human face. We must also have openness—greater openness—about the place of technology in all polities if human and environmental rights are the goal. Yet for such Bolshevik leaders as Lenin and Trotsky, Poland's Boleslaw Bierut and Bulgaria's Georgi Dimitrov, and of course North Korea's Kim Il Sung, technology was no more and no less than a solution to the great problems facing the early USSR.

The effort to mobilize the labor force and yet to plan every aspect of economic, political, and ideological life led to a series of inherent contradictions in the economies of East Central Europe. They became economies of shortages, lines, and bottlenecks, and then campaigns to solve the bottlenecks. The planned economies that so faithfully strove to embrace advanced technology gave birth to a new dialectic, for a campaign in one area meant a shortage in another; a shortage in one area led to criticism of economic managers and party leaders now "responsible" for that shortage who might be accused of malfeasance, deviations, or even sabotage and wrecking; and all of this exacerbated tension between the center and the localities, the managers and the workers, the workers and the peasants, and anyone else who was paying attention. The worker and the peasant paid attention to the glories of socialist technologies and the shortages of necessities that accompanied their construction.

Socialist technology differed from capitalist technology literally and figuratively in a variety of ways and for a variety of reasons. Socialist leaders directed it toward solving industrial, extraction, smelting, grinding, pouring, and other important tasks that they placed before the worker. They paid less attention to housing, road, sewerage and water treatment, communications, medical, and other technologies. Choosing autarky under Stalin, they had to seek indigenous sources of innovation. They succeeded in areas of importance to the power of the state—rocketry, nuclear power, metallurgy, and so on. They employed rudimentary but functional designs and approaches. But they often failed to embrace

designs that placed emphasis on safety and environment. They were fearful of the influence of so-called bourgeois experts and of continued reliance on the West for the innovative push. When they turned to capitalist technology through trade, espionage, and reverse engineering, they committed the economy to playing a constant game of catch-up and surpass—or "reach and surpass," as the Stalinist slogan exhorted them. They generally resorted instead to campaigns to make the best of capital and labor inputs without considering how they might employ either input more rationally. If a tractor, skidder, hoist, turbine, or some other technology worked, then it worked well enough. The pressure on engineers to meet targets discouraged them from seeking innovations that might slow plan fulfillment in the short run but would have paid dividends in the long run.

It may be that the employment of slave labor in the gulag system of the 1930s, 1940s, and early 1950s convinced leaders and engineers alike of the expendability of human life and of the feasibility of relying on brute human power equipped with hand tools and insufficiently provided with machines. How else can we understand the fact that Russian historians and chroniclers of the construction of the White Sea–Baltic Sea Canal to this day praise the slave laborers for figuring out how to organize themselves to use wheelbarrows and sledgehammers to cut and move stone?

Of course, functional technologies have universal attributes based on various laws of physics and chemistry, geology, hydrology, heat engineering, and so on. Strength, weight, durability and availability of materials, local climatic and geophysical conditions, and so many other factors require that all successful canals, dams, buildings, airplanes, reactors, steel mills, etc., resemble each other or they would not work. Thus, when Stalin and his followers insisted that socialist technology existed, he meant that it served the worker, not the exploiting class, and that it could be mastered in a short time for universal application within the countries of socialism. But in this way, once again, the socialist system discouraged innovations that took into consideration geographic, seismological, climatic, and other differences. Leaders feared spontaneity not only in politics, but in engineering, and thus contributed to the belief that one technology was appropriate not only for an entire sector of the economy but for the entire country and the entire socialist world. This led them frequently to run roughshod over local, regional, and national programs, and roughshod over the worker, male or female, as they tried to force them to conform to technological norms established in Moscow, Warsaw, Kyiv, Leningrad, Budapest, and Sofia state committees for standards, construction, and engineering.

Masabikh Akhunov (1928–2008), "The Dnepr Hydroelectric Power Station," 1970. Innocent Vladimir Lenin, Leon Trotsky, and other Bolshevik leaders were technological utopians. They believed in the power of technology to create communism. The slogan imposed on the Dnepr Hydroelectric Power Station in this linocut—"Communism—Is Soviet power plus Electrification of the Country"—reveals this sentiment exactly. Courtesy of the Allan Gamburg Gallery, Moscow, Russia.

WOULD TROTSKY WEAR A BLUETOOTH?

Technological Utopianism in the Soviet Union in the 1920s

We are accustomed to reading about the central role of technology in the mindset of North Americans and Europeans. Technology serves both as a symbol of modernity and national achievement and as an engine of economic progress. Political leaders, engineers, writers, and journalists have consciously embraced the railroad, the automobile, magnificent hydroelectric power stations and other major public waterworks, sleek airplanes, the powerful nuclear reactor, and the rocket ship as confirmation of a society's manifest destiny, its ability to conquer all frontiers, its superiority over other nations, and a sign of the legitimacy of its leaders. Whether recognizing it or not, they have embraced an Enlightenment view of nature, and not only the desirability of controlling it for the betterment of humankind, but the ability to do so. Technological progress represents to many of these individuals the highest form of civilization. They believe in an almost moral imperative to bring the benefits of modern technology to those "backward" people, nations, and societies that must manage without it. They also have economic, geopolitical, and other reasons for promoting technological development elsewhere; they have sold hydroelectric technology to Brazil and Egypt, green revolution seeds and fertilizers to Indonesia and India, and phar-

maceuticals to other countries, all in the name of progress and democracy. Remember the admonishment of David Lilienthal, chairman of the Tennessee Valley Authority (TVA), that the TVA—the New Deal program to bring figurative and literal illumination to the hollows of Appalachia, end poverty, overcome illiteracy, and improve agricultural production—was a sign of "Democracy on the March."[1]

In socialist systems, many of these same beliefs held. For leaders and engineers, technology was unquestionably a sign of modernity. Because the nations that have followed the socialist path have invariably been agricultural, they sought to acquire the most modern industrial technology as rapidly as possible. They believed that it would transform backward peasants into conscious citizens, simultaneously providing them with life's necessities and thus securing their loyalty. They sought advanced technology for strategic considerations since they were surrounded by "hostile" capitalist countries. After all, American and British troops intervened in Russia during the civil war, later Germany invaded the USSR, and indeed North Korea has faced relentless economic pressure and aggressive rhetoric from such nations as the United States. Similarly, technology served as a panacea for such economic problems as drought and repeated agricultural failure, inadequate transportation and communications infrastructure, and low life expectancy. Hydroelectricity and irrigation would end the scourges of flood, draught, and famine. From Lenin to Stalin to Kim Il Sung, technology found a central place in ambitious, even utopian development programs.

At the same time, these same leaders frequently found it expedient to forget that technology is not value-neutral, but embodies political and economic considerations. As a result, they encountered significant difficulties in what they expected would be a simple matter of lifting up, extracting, and importing modern technology from the leading capitalist nations, even as they anticipated industrialization without the great human and environmental costs that capitalist nations experienced—or so they promised the workers. In socialist and capitalist nations alike, the embrace of modern technology led to such great social disruptions as cathartic migration from the countryside to urban centers, where the workers faced crowded, dirty housing in spite of the best efforts to provide them with spacious, clean homes and apartments. Migration ripped families apart, especially since it often resulted from forced collectivization in socialist nations. Under socialism, workers received poor pay and had few consumer goods. Millions starved in the process of industrialization and collectivization in

the USSR in the 1930s, and again after World War II in North Korea and elsewhere. At work, they confronted noise, pollution, and accidents at levels likely significantly higher than in capitalist factories.

Believing that they faced opposition from all sides and seeing the need to resurrect the economy at all costs, Communist Party leaders often felt compelled to put the needs of the machine ahead of the needs of the worker. They bridled at the call for workers' management of the means of production when workers' management meant plummeting productivity. When the Workers' Opposition movement in Soviet Russia in 1920 and 1921 demanded the replacement of so-called bourgeois managers with communist workers, Lenin and the Bolsheviks rejected their concerns, even expelling members of the opposition from the party and harassing the movement's leaders. Lenin, Trotsky, and other Bolshevik leaders were correct in noting that workers often misunderstood how to use machinery and equipment or to organize labor in factories, and they were rarely a source of innovative impulses. In this atmosphere, the leaders made fateful choices about the importance of modernizing rapidly on the basis of modern, and often large-scale, technological systems. This drained scarce resources from other sectors of the economy that might have benefited the worker more directly and certainly more immediately. Socialist leaders overestimated the power of technology to transform their societies overnight into paradises of plenty and underestimated its power to disrupt society's social, cultural, and political structures. But while Lenin and Trotsky stressed the universal characteristics of technology, Stalin argued that socialist technology as distinct from capitalist must be created in the USSR, and he insisted that it would be built within a few short years.

Culture and Technology in the Russian Revolution

When the morning whistles resound over the workers' suburbs,
It is not at all a summons to slavery. It is the song of the future.

. . . . . .

A million workers seize the hammers at the same moment.
Our first blows thunder in accord.
What is it that the whistles sing?
It is the morning hymn to unity.

ALEKSEI GASTEV, "The Song of the Workers' Blow"[2]

A healthy kind of technological utopianism burst forth after the Russian Revolution. Rene Fullop-Miller, Kendall Bailes, Richard Stites, and others have described its manifestation in public displays, exhibitions, and festivals, a number of which were sponsored or organized by the Bolsheviks, but many others of which were spontaneous and inspired by a wide variety of cultural and social movements unleashed by the revolution. The Bolsheviks saw technology as the solution to falling industrial production and declining productivity of labor. Anarchy had spread through the factory when workers' committees threw out their former bosses, and machinery broke down with no one to fix it. Unskilled laborers ruined equipment. Production fell idle. The Bolsheviks believed that various techniques and technologies from the West might be employed to great benefit in fighting the precarious situation. In the absence of new capital, Taylorist methods (known in Soviet parlance as NOT, or *Nauchnaia Organizatsiia Truda*) would ensure that the worker more efficiently used his energy in the workplace to operate existing equipment. Next, the introduction of the assembly line ("*Fordizm*" in the Russian) would facilitate mass production of inexpensive and reliable necessities.

The Bolsheviks were fascinated by America's position as the "paradise of machinery" and found the modern assembly line of Ford especially virtuous. They were convinced that under capitalism the worker could never be a natural appendage of the machine. He would fight Taylorism and its "strictly enforced psycho-technical system of work." Under socialism, Taylorism served the worker. For Russia, with scarcely any modern industry (and little of that large scale), a small working class, and the great masses of the peasantry still working the soil with the most primitive tools, where "Asiatic medieval methods of work and organization prevail," Fulop-Miller wrote, "American mechanization" was "the loftiest expression of human perfection."[3] The former "medieval methods of work" would be replaced with a technical culture greater than that in America, Germany, or France. The entire state would be electrified; motor plows, tractors, and threshing machines would be sent to the remotest districts, with political instructors accompanying the machines to the countryside to convert the peasant to the new way.

Outside of Bolshevik circles, other intellectuals embraced the machine. Alexei Gastev, a radical involved in workers' causes since the 1890s, was fascinated with industrial production as the basis of new ways of living, working, and thinking and spread ideas of proletarian culture after the revolution. In such poems as "We Grow out of Iron" he celebrated a new relationship between

workers and technology, with collective effort turning onerous work into celebration. In the Proletarian Culture movement (*Proletkult*), Gastev joined other activists, poets, and playwrights who exalted the machine. Artists and musicians wrote concerts and organized processions of steam whistles and factory sirens. They all saw a future of machine cities based on engineering culture. Proletkult promoted uniformity, standardization, and collectivism—and thereby true equality under socialism—at home and at work.

Given America's position as the greatest technological power, and given its seeming mastery of standardization, Gastev and others, including Lenin, were drawn to its technology; to its assembly lines, skyscrapers, automobiles, and tractors; and to the iconic leaders of its technology, in particular Henry Ford and Frederick Winslow Taylor.[4] Ford's *My Life* was translated into Russian a half-dozen times and became a best seller. Soviet Fordists—and other individuals who found the cantankerous Ford to be an industrial hero—ignored his rabid anticommunism and anti-Semitism. They believed that his ideas about the conveyor belt for the factory were apolitical and could be applied to bring order to production in any society.[5] Similarly, Taylor's *Principles of Scientific Management* (1911) promised to maximize industrial output and end disputes between workers and managers; in addition, Taylor's book claimed that these principles might be applied to a broad range of human activities with equal aplomb—housework and the kitchen, resource management, even government. While failing in each of these areas (workers rejected the further diminution of their power over the production process inherent in time-motion studies conducted by "objective" experts in white coats holding stopwatches to inform them how best to economize their labor on the shop floor), Taylorism found broad response in the Soviet Union, as did fascination with American technology generally.[6]

The Bolsheviks promoted both economic and cultural revolution through technology. They struggled with illiteracy, they fought to bring modern medicine to the masses, they attacked religious belief, and at least initially they supported women's liberation from traditional roles while ridiculing the patriarchal family. (Under Stalin, the Bolsheviks returned to the nuclear family as an institution of stability and political conservatism.) Trotsky advocated a redoubled effort to use the media in a variety of areas of "cultural construction" and propaganda toward the ends of cultural and economic revolution. He believed that the proletarian newspaper correspondent, or *rabkor*, was a "key factor of cultural reform." Trotsky asserted the following: "Yes, the monopoly of the press is in the hands of that party through which the workers realize their power, through

dictatorship. The press is one of the most important instruments of class dictatorship. This weapon preserves, however, its vital force at the time when it serves not only the dissemination of ideas, slogans and resolutions from above, but the free expression of opinions, evaluations, and criticism from below. Yes, we have the free expression from those below immeasurably greater than in any capitalist country."[7] Recognizing problems of illiteracy, he called for new newspapers, with better paper, easier to read print, and better content. Science, technology, and literature were the means to fight lack of discipline in all its forms.[8]

Yet the great disparity between the aims of the Bolsheviks and their preliminary conditions of a backward and war-torn economy belabored efforts to create the workers' paradise. As Fullop-Miller commented, they faced the daunting task of reeducating the peasant against his fatalistic pessimism, his anticipation of agricultural failure, and his fear of innovation in the effort "to inculcate a technico-mechanical spirit, to end patriarchal and primitive methods of work" with modern, American machines. They had no industry and no trained technicians but still exhibited a "naively enthusiastic infatuation [for] the simplest technical achievements, the religious ecstasy with which they rave about 'rationalized industry,' 'mechanization,' and 'complete automata.'"[9] The Bolsheviks believed that they could perfect this "technical wonderworld" simply by imposing socialist productive relations and Bolshevik willpower on the machine. Given this view, Fullop-Miller observes, "The simplest objects of technology immediately became sacred religious paraphernalia and fetishes for the orthodox Bolshevists." They worshiped the machine; they were "modern ecstatics" of rationalized labor, of bliss with belts, pistons, valves, and flywheels.[10]

While the genesis of Taylorist and Fordist systems and technologies was the capitalist system, given socialist productive relations they would be employed to the full benefit of the work. In a word, through technology the Bolsheviks set out to transform the *muzhik*, or peasant, and the worker into allies of Soviet power. Literacy campaigns focused not only on reading but on teaching public health measures, good work habits, and dedication to the collective. To promote new thinking, the Bolsheviks used the political poster, often with technological themes. The poster connected with the barely literate worker through vivid colors and designs and simple messages. In posters such technological images as machines, tractors, and entire factory edifices replaced religious figures and themes; the poster supplanted the religious icon. Sports festivals and spectacles in which the machine occupied a prominent position brought workers and peasants together, giving the authorities direct access to them for propaganda purposes. At the myriad large-scale construction sites for dams, steel mills, and entire cities that were the centerpiece of Stalinist industrialization, the authorities extended the lesson of technological enthusiasm among inexperienced workers who streamed into those sites.

Amerikanizm: Tractors and Taylors

In spite of their determination, it took decades to create technological culture among the Soviet masses. Maurice Hindus was born in a Russian village "so deaf" that he did not see a train or a lightbulb until he left for America at the age of fourteen. He returned to Russia in the 1920s almost annually, visiting those backward villages to follow the course of the revolution. One hot Sunday afternoon he strayed into a small town on the Volga River and ran into a "bizarre" wedding procession coursing back and forth through the village with bride and groom sitting in a small cart drawn not by a troika of horses but by a Fordson tractor, and this in a village "where some folk still shared their abodes with pigs and chickens." Posters of Marx, Lenin, Kalinin, and other Bolshevik heroes adorned the cart and tractor. For Hindus this was another confirmation of the glowing admiration of Russians for America, dating to the first days of the revolution when the American Relief Administration, under the direction of the capitalist engineer and later president Herbert Hoover, saved millions of peasants from starvation.[11] The *muzhik* and the Bolshevik leader both wanted American technology to secure the success of the revolution.

In so many ways the pursuit of "mechanical civilization" in the USSR involved the effort to assimilate West European innovations and to "Americanize" production and attitudes toward work. Strong interest in America, its business practices and industry, predated the Russian Revolution: for example, Count Sergei Witte and others promoted the Tsarist Empire's industrialization through the Trans-Siberian railroad and other state-sponsored programs.[12] At first U.S. businesses had little interest in exporting to Russia for such reasons as poor terms of trade, geographical distance, and domination of the foreign market by France and Germany. The Soviets, of course, rejected American business practices as capitalistic and inappropriate but had great interest in its machinery, equipment, economies of scale, and techniques of labor organization; in Taylorism; in Fordist mass production assembly line techniques; and so on. Under Lenin, and indeed until the early 1930s, the Soviets frequently engaged American experts and purchased American technology. They wished to avoid depen-

dence on Germany and were determined to develop indigenous industry—or be crushed by the capitalists. They needed to "master the highest technology," which meant American technology, including its industrial methods.[13]

While the U.S. government failed to recognize the USSR diplomatically until 1933 (the last major power to do so), American businesses were ultimately less reluctant to engage the Soviets. The Soviets sought out trade and other agreements in the mining, metallurgy, and machine-building industries, energy and agricultural sectors that they saw as the key to both American success and the success of the first five-year plans. Kendall Bailes writes that Bolshevik leaders did not trust their own engineers to be up to date with American achievements and found them to be too class or caste conscious. But they wanted American technology and expertise, and scores of American engineers journeyed to Russia—Hugh Cooper helping to build the Dniepr hydroelectric power station, John Scott working at Magnitogorsk, and many others. The Gorky Automobile Factory was modeled on Ford's River Rouge Plant. The engineer I. P. Bardin, who had worked at the Gary, Indiana, steel mills, chose them as a model for Magnitogorsk, while Gipromez, the Leningrad Design Institute for the Metallurgical Industry, had 2,000 employees, including 400 America engineers. The enlisting of the Cleveland, Ohio, design firm of McKee and Company in 1930 in the construction of Magnitogorsk reflected the desire to use "the experience of American technology that was progressive for that time." The Soviet officials came to believe that McKee "dragged out the term" of work; they replaced McKee with the indigenous Gipromez in 1932, and "real work began," including the production of iron in 1933. Yet when the Bolsheviks orchestrated show trials of western engineers in the 1930s, shockingly no American engineer was accused of wrecking and brought up on charges like the European (and Soviet) engineers.[14]

The satirists Ilya Ilf and Evgenii Petrov commented on the allure of America in *One-Storey America*, based on their 1936 cross-country road trip. While other Soviet authors had become increasingly negative about America, and to be sure Ilf and Petrov criticized American materialism and superficiality, they also reveled in America's technology, order, and cleanliness, even among the simple folks who lived not in the skyscrapers symbolic of capitalist power, but in one-storey houses. They traveled to Schenectady, New York, and the General Electric Corporation, where they were shocked to learn how much autonomy and financing engineers had to conduct research seemingly without immediate value to GE. They dropped in on Henry Ford in Dearborn, Michigan. They noted

the following: "The Fordist method of work long ago has moved beyond the manufacture of automobiles to other objects. This system to a great degree had an influence on the life of the world. But the man, who thought up the system, did not evolve with it. He remains what he was, a mechanical engineer. To be sure a brilliant mechanical engineer, but no more. And at the same time as his action and the actions of other industrialists turned America into a country where no one knows what will happen tomorrow, he obstinately tells himself and those around him, 'This doesn't concern me. I have my own problem. I make automobiles.'"[15]

In agriculture, the legendary American tractor was the focus of interest. The Soviets established the Amtorg Trading Corporation in May 1924 to procure agricultural and other machinery, and they opened offices in several American cities. Amtorg engaged in small-scale acquisitions until the Soviets switched over from concessions to technical assistance contracts in 1928. They hired hundreds of engineers for employment in the USSR. Dozens worked at the Cheliabinsk Tractor Plant, twenty-one with the Tractor Plant Construction Trust, sixteen with the Stalingrad Tractor Factory, and twelve with the Kharkiv Tractor Factory. These engineers were involved primarily with agricultural machinery industry and to a lesser extent with the fertilizer industry and in irrigation. American firms shipped farm equipment; assisted in the design, construction, equipping, and operation of machinery plants; and offered management help in adapting farms to a mechanized agriculture.[16]

In absolute numbers and symbolically, the tractor was the *technology de résistance*. Dalrymple writes, "Seldom has a major agricultural technology been adopted so quickly and on such a vast scale as was the tractor in Soviet Russia." In the absence of a domestic industry, the USSR imported huge numbers of tractors toward the end of modernization of agriculture. The United States was the only nation with the capacity to supply the tractors in the necessary numbers. From 1924 to 1933, 86,377 American tractors were shipped to the Soviet Union, nearly 23,000 in each of the peak years of 1930 and 1931. To ensure proper assembly and use of tractors, Soviet technicians visited U.S. plants, American and Soviet engineers visited sites to ensure working order, and such firms as International Harvester, Deere and Company, Caterpillar, and Advance Rumley opened training schools and tractor repair shops. The Soviets also turned to American technology and expertise to expand domestic farm equipment production. The Detroit firm of Albert Kahn, which designed the Ford plant, also provided the blueprints for the Stalingrad Tractor Factory, while

Leon Swajian, who worked on construction of River Rouge, was involved in the Kharkov Tractor Factory and later at Cheliabinsk.[17]

Soviet industry turned to American designers and engineers to expand production of their own tractors at the Putilov Steel Works in Leningrad (for example, the Krasnyi Putilovets, "a rather poor replica of the Fordson" that the Soviets had reverse-engineered poorly and at greater expense than import of a Fordson would have cost) and in Cheliabinsk (with the Stalinets 60, a ten-ton replica of the Caterpillar that was a crawler tractor, less nimble, but grew out of military designs for tanks). To a smaller extent, the Soviets worked with American companies to expand the fertilizer industry, in particular with Du Pont of Wilmington, Delaware, and Nitrogen Engineering Corporation of New York. Americans were also involved with two substantial irrigation projects: the Central Asian Water Trust (Sredazvodkhoz) and the Transcaucasian Water Trust (Zakvodhoz). For example, Arthur Powell Davis, former director of the U.S. Bureau of Reclamation, served as chief consulting engineer with Sredazvodkhoz.[18]

In a decade the number of tractors increased from 1,000 to over 200,000, a fact "all the more remarkable because it took place in a rural economy which had, from a technological point of view, changed little from the Middle Ages." These tractors later enabled rapid collectivization. The Soviet government invited Ford to send a delegation to Russia in the hope that they could interest him in erecting a factory there. The delegation rejected the plan, and Fordsons were too small for the collective farms that would be established. The Soviets therefore turned to larger tractors with more horsepower from International Harvester, John Deere, Case, and Allis-Chalmers. This suggests that, although the tractor was American in design, and the Soviets acquired it through turnkey plants or through reverse engineering, it could serve either capitalism or socialism.[19]

American specialists reported that Soviet tractors did not meet American standards of quality and that maintenance was still a severe problem owing to substandard raw materials and severe production difficulties. The problems included leaking radiators, poorly cast cylinder heads, loose bearings, broken valve springs, unsatisfactory threading on spark plugs, and so on.[20] The poor quality of the tractors was accentuated by their misuse, even though initially American agricultural specialists were engaged in training Russian peasants how to use the tractor properly. The Russians lacked mechanical background. They took little interest in proper operation because the tractors were owned by the

state, not the operator. Hindus, after a tour through his home area, spoke of "the reckless treatment of machinery on all the socialized lands." He continued: "The resulting breakage is colossal. Fleets of disabled tractors dot the Russian landscape . . . machines are left with no cover over them in yards and in far away fields, exposed to the devastation of wind, rain and sun."[21]

The tractor was important as a symbol of the unification of industry with agriculture. Lenin saw more in the tractor than just an implement for tilling the soil; he saw it as a vehicle for luring the peasantry to communism. On March 23, 1919, he told the delegates to the Eighth Party Congress that tractors would create communism: "If we could give 100,000 first class tractors tomorrow, provide them with gasoline, with mechanics (you all know quite well this is a fantasy), then the middle peasant would say, 'I am for communism.'" The peasant, Lenin continued, "needs the industry of the city, without it he cannot live."[22]

Beyond *Fordizm* and *Amerikanizm*, beyond tractors and factories, technological enthusiasm had a number of cultural manifestations. Everywhere one went, one encountered street names honoring technology or workers. Stamps and posters were based on technological themes.[23] New words and names for organizations appeared that were often drawn from bits and pieces of other words and left no doubt about the organizations' functions (Sredazgiprovodkhlopok—the Central Asia Water Melioration and Cotton Institute). Peasant enthusiasts named their children "Forge" (*Domna*), "Electrification," "Tractor." Such journals as *Novyi Mir*, *Sibirskie Ogni*, and later *Raduga*, *Angara*, and many others also rejoiced in the modern machine in publication of poetry and literature. Writers, critics, and political authorities used this venue to discuss the anticipated achievements under Soviet power and the political and social role of technology. Stalin's "poet of the revolution," Vladimir Mayakovsky, spent three months in the United States, visiting New York, Chicago, Detroit, Philadelphia, Pittsburgh, and Cleveland; giving readings and lectures and joining in the workers' struggle; and penning *Poems of America*, which included "Chicago" and "Brooklyn Bridge," in the latter praising the bridge as "a paw of steel" that would bring "the seas and the prairies" into a single clasp, suggesting that modern technology would supplant religion ("as a crazed believer enters a church") and would bring the shamanistic people of the north into the Soviet fold ("I stare as an Eskimo gapes at a train").[24]

The dystopian side of the headlong rush to embrace technology would be felt increasingly in the Stalin period, although it was evident already with the first days of the revolution. The Bolsheviks increasingly poured resources into large-

scale technological projects, while funding for housing, food, heating, and public health lagged, even though they were at much higher levels than before the revolution. Workers did not experience joy; they suffered at every work site from exposure to machinery, pollution, and the elements, and their low wages and long hours also gave little reason to celebrate. They abused the machines as much as the machines abused them. The situation for engineers was no better. Party officials, perhaps fearing their potential power and certainly distressed by the pace of industrialization (since superhuman pace was insufficient), attacked specialists for their alleged transgressions. The resulting loss of autonomy over research, innovation, and diffusion created extremely challenging conditions for engineers and scientists in which to work. If at first Stalin had declared that the Bolshevik Revolution depended on technology ("Technology decides everything!"), he came to realize that getting peasants, workers, and specialists to fulfill their obligations to technology was crucial ("Cadres decide everything!"). And yet he still emphasized investment in large-scale technologies, always technologies, and rarely in social overhead capital of benefit to the worker. The darkest vision of a society in which the state used technology to dominate human life to the depth of our very feelings, Evgenii Zamiatyn's *We* (1921), was actually written in response to events and experiences before the revolution. But Lenin and Trotsky shared none of these dark visions of technology.

Lenin Electrified

Vladimir Lenin unyieldingly attacked opponents. He hated compromise. He insisted in *What Is To Be Done?* (1903) that only devoted, professional revolutionaries had a role in his party. He rejected the "god-building movement" of Maxim Gorky, Anatoli Lunacharsky, and others that sought to "deify" the liberated worker after the revolution as no better than any other reactionary religious belief. He condemned as naive the Proletkultists for denying the value of such bourgeois institutions as science and technology in the construction of socialism; after all, Marxism grew out of capitalist society. He described the violent means necessary to establish the proletarian dictatorship in *State and Revolution* (1917). He presided over a bloody coup to seize power and authorized the formation of the Extraordinary Committee, the Cheka, under Felix Dzerzhinski, to terrorize enemies, including by carrying out summary executions. He methodically issued proclamations to seize land, confiscate possessions, and

nationalize industry and banks to cement Bolshevik control over economy and society. He has deservedly earned a reputation for hard-nosed, pragmatic, and even opportunistic policies, all intended to maintain the Bolshevik dictatorship. For these reasons many people find it hard to believe that Lenin was a technological utopian. Yet Lenin entertained visions of a glorious communist future, a land of contented, productive workers; of well-illuminated, spacious, and well-ventilated factories; of peasants toiling in the fields replaced by electrical machines that increased yields while lightening the burden on the *muzhik*. At the base of all these visions stood such technologies and techniques as electrification and Taylorist time-motion studies, roads, railroads, and communication systems.

On the eve of the revolution, Russian roads and railroads were the worst in Europe. There were no more than 25,000 kilometers of highway, and most turned to mud for much of the year. Boat travel was important, yet even during the good seasons it took months to ship grain to its final destination. Between 1890 and 1913 Russia was the faster builder of railroads in Europe, adding 31,000 kilometers to the system, but this was insufficient to meet the needs of a rapidly industrializing society and totally inadequate to handle the vast numbers of men and supplies during World War I. By the end of 1915, 4.4 million Russian men had been killed, wounded, or taken prisoner, and the railroad was choked with replacements, sick, wounded, and soon deserters. Disorganization encroached on the system, and supplies ultimately failed to reach the front or the cities. Long lines formed for fuel and food. The railroad became the major vehicle for the spread of disorder, bottlenecks, and dissatisfaction with the Tsarist regime on the eve of the revolution.[25]

The telegraph was an instrument of revolution; the telephone, post, and radio played a minor role. On the eve of the revolution, the empire had only 7,618 post offices in Russia, 80 percent of them in European Russia. Many towns were dozens of kilometers from the nearest post office. By 1870, however, 714 telegraph offices and 91,000 kilometers of line were added. The Tsarist government feared information and desired to repress communications; thus, it heavily censured the post and telegraph, so much so that when Empress Aleksandra sent telegrams to Tsar Nicholas at the front, they came back marked "Whereabouts of the addressee unknown." The Provisional Government ended censorship; sought to improve post, telephone, and telegraph service; and was fortunate to have the support of workers in this industry—railway workers tended to be Bol-

shevik supporters. However, as the situation in the economy worsened throughout the summer, many of the other workers in transport and communications, too, grew sympathetic to Bolshevik calls for "Bread, Peace and Land."[26]

Lenin recognized the great possibilities of control of media for propaganda purposes and feared access to "the means of communications" by all others. Lenin understood perfectly that loyal Bolshevik soldiers must immediately seize bridges, printing presses, and telephone exchanges during the October 1917 coup. The railroad, post, and telegraph also must fall into Bolshevik hands. The control of these means of communication ensured that the successful seizure of power was relatively bloodless, if not preventing a long, bitter, and bloody civil war. Lenin realized that he must use them as a tool to link the nation and contribute to the fanning of the revolution out from Petrograd. After seizing power, it took two to three weeks for the Bolsheviks to force civil servants to follow their orders and issue their decrees, but eventually they controlled this important communications nexus, too.

Once the Bolsheviks seized power, Lenin faced the pressing problems of world war opposition from the right and left, then civil war, and precipitously failing industrial production. Inadequate food and fuel deliveries threatened the Bolsheviks' tenuous hold over the cities, forcing them to turn to forced confiscations by armed soldiers in the countryside. In these conditions Lenin still found time to think about how best to promote the diffusion of modern technology to overcome these problems. In 1920 Lenin promoted the fifteen-year State Plan for the Electrification of Russia (in Russian known as GOELRO), with Gleb Krzhizhanovsky as its first director and later head of the State Planning Administration, Gosplan. Lenin considered GOELRO a kind of "second party program." Some 200 engineers, most of whom had clamored for a national electrification plan since before the revolution, joined Krzhizhanovsky in working out the details of GOELRO. They premised the system on central production and distribution stations (largely peat and increasingly hydroelectricity) serving eight districts. GOELRO would overcome extremely low capacity in comparison with Europe and the United States and miserly per capita production. The plan required a complete technological revolution to replace or rebuild outdated and small plants in a miserable state of repair. While modest by today's standards, GOELRO involved the construction of a series of central power stations to increase energy capacity and production four and a half times, a goal achieved essentially by 1931.[27] To be clear, electricity was a panacea; it would increase productivity of labor, ease onerous work, rationalize the workplace, and transform agriculture. Krzhizhanovsky recalled nearly forty years later that "GOELRO was the banner of the economic rebirth of the country, of the first attempt of planning of the entire national economic complex on the basis of its technological reconstruction on the basis of advanced technology—the technology of electricity."[28]

Like Lenin, Trotsky saw electrification as a key to the country's future. Trotsky spent several months in the United States, and he remarked on the conveniences of life that were rare even among European workers: electric lights, gas cooking ranges, baths, telephones, automatic service elevators, even a chute for the garbage, and of course the automobile;[29] meanwhile, the Soviet worker toiled manually to provide firewood, peat, and shale. Impressed apparently by the oil-based economy, Trotsky found peat to be an old-fashioned source of energy and looked forward to the day at the end of the civil war when the Bolsheviks had secured the Don Basin, the Northern Caucasus, Baku, and Embensk oil. Until then, peat had to suffice.[30]

In a speech at the Eighth Congress of Soviets in 1921, Trotsky spoke about the need for a unified economic plan and the central place of electrification in that plan. Electricity had both economic and symbolic significance. It "attracts the *muzhik* to the unified economic plan," while unifying the economy. To this point, economic activity occurred in "isolated islands in the ocean of disconnected peasant economy." The solution was to integrate the peasant economy into a socialist one through planning, simultaneously securing the peasant's dependency on the government. It was necessary for the peasantry "to receive power that moves, heats and illuminates from central stations along power lines; necessary that the thoughts of the peasantry were turned to technology, to culture, and this may be solved most surely of all and best of all through the means of electrification, through the means of the provision of goods and services of the countryside, of rural workshops, schools, peasant huts, of electrical energy for work, for illumination, and may, in the future, for cooking, food and heating." Trotsky concluded that acceleration of the tempo of electrification was the key to turning the peasant "to technical progress, to culture. Without the solution of the problem, the socialist economy will be a series of disconnected islands in the ocean of agriculture."[31]

The Bolsheviks focused on other technologies as well. They quickly brought the means of communication under their control and used them for regime purposes. They shut down opposition newspapers of parties on the right, the Socialist Revolutionaries and Mensheviks, and even those of their allies when

the tone against the regime was too sharp. Maxim Gorky's *Novaia Zhizn'* (*The New Life*) published articles increasingly critical of Lenin's undemocratic methods, the bureaucratization of government life, and the need to save Russia's intelligentsia from complete loss owing to famine, ill health, and displacement at the hands of the working class; although a longtime associate of his, Lenin shut Gorky's paper down. The Bolsheviks saw the media as a tool not only of repression but of education and exaltation. They sought to combat backwardness in the face of daunting obstacles of illiteracy, intervention, and civil war. They encouraged and took advantage of genuine popular enthusiasm in a variety of campaigns—against alcoholism and illiteracy, for new programs in public health. They organized "agitational" trains and ships, processions of automobiles and tractors. They intended both to persuade the masses to support them and also to change mass consciousness in the effort to create a new Soviet man and woman. The Bolsheviks used the press, books, films, and posters with great success in perhaps the world's first effort at mass politics.[32] By the late 1920s the Bolsheviks controlled all publishing houses fully (and required all typewriters to be registered with the authorities) and the press, radio, and film. The language of state control was socialist realism, a genre of art, literature, and music. Of course, through the media party officials carefully orchestrated cults of Lenin and Stalin and other infallible party leaders so that no one had reason to question the legitimacy of the communists.

Lenin embraced time-motion studies in the form of Taylorism as another technological fix for the economy.[33] Rhetorically, Lenin and other Bolshevik leaders saw the application of Taylorism as a way to raise productivity while easing the labor of the worker, who would lose superfluous, outmoded motions. But in fact, the Scientific Organization of Labor (NOT) was intended to eliminate "laziness, panic and wildness, vice," to internalize "success and efficiency, awareness and attentiveness," all the while giving researchers and managers control of the use of tools, timing, tasks, and organization. Alexei Gastev, who penned the article on *Fordizm* published in the first edition of the *Great Soviet Encyclopedia* in 1937, shortly before his arrest and disappearance in the Gulag, gained Lenin's approval to establish an institute for NOT, while a quasi-voluntary and national "Time League" formed, and its columns filled regional and local newspapers with advice. The *Herald of the Communist Academy of Sciences*, a center of Marxist social scientific thought, briefly offered a section of the journal on Taylorism.[34]

Trotsky also embraced Taylorism as a value-neutral tool of capitalism that could be applied to the socialist economy with great effect. Trotsky noted poor performance and lag in all regions of economy. The Soviet iron and textile industries produced at best one-third of the Tsarist level. In addition, the labor force was in disarray, with the most capable, energetic, and talented elements of the working class drawn into administrative work and into the army. About half the labor force was truant, and the worker spent too much time and energy on the acquisition of food and other necessities. An American engineer, Kelly, a Taylorist and supporter of Soviet power, studied the situation and concluded that the Bolsheviks could apply Taylorism scientifically to the socialist economy with good results.[35]

Trotsky recognized the close connection between military methods and Taylorism. In the United States, the military played a central role in the development of Taylorism, applying Taylorist methods on a large scale and learning firsthand that the worker rejected the methods as deskilling him and weakening his position vis-à-vis the factory manager. At the Watertown, Massachusetts, arsenal, officials applied Taylorism to improve the production of munitions. In spite of the worker's rejection of Taylorism in Watertown, Trotsky believed that it had important applications under socialism. He noted that many of the military techniques applied to the labor force during War Communism, when the Bolsheviks were forced to "militarize" production, were in essence Taylorist, a "more precise form of exploitation of labor activity, the most ruthless, so that each movement and each breath is calculated." Trotsky compared the disorganized movement of a crowd with the rapid, coordinated movement of a regiment to argue that Taylorism was a positive, creative force that could be applied to industry. He wrote, "I do not doubt that those tens of thousands of workers return from our army that they built not as slaves, but built consciously, will transfer their habits into economy and into industry." He continued, "The socialist manager should assimilate this side of Taylorism fully."[36] Taylorism and the concomitant militarization of labor would overcome the problems of unskilled labor and the breakdown of machinery that followed the war and revolution.[37]

The embrace of NOT indicated yet again that the Bolsheviks believed that technique could be transferred from capitalism to socialism successfully. Socialist productive relations guaranteed that the worker benefited from NOT; engineers determined the maximum output of the human organism in laboratory settings to serve the proletariat, not profit, and transferred that knowledge to the factory and field. NOT simultaneously overcame the outmoded attitude of

the worker. Unfortunately, under socialism, too, while the primary goal of NOT was the improvement of labor efficiency to give the worker the benefit of science, it also involved regimentation of every aspect of labor that the worker rejected as deskilling and inhuman. Under Stalin, Soviet officials determined that NOT gave suspect engineers, not reliable communist managers, too much control over the pace and organization of work, and they closed Gastev's institute.

Yet in this earlier period, scientists and engineers retained autonomy. Lenin and Trotsky believed that scientists and engineers were "spontaneous materialists" by virtue of their craft and their rejection of superstition, the supernatural, and other idealist trends. Lenin presided over the rapid expansion of the scientific enterprise through Glavnauka (the Main Administration for Science of the Commissariat of the Enlightenment) and NTO (the Scientific-Technical Department of the Supreme Economic Council). Glavnauka officials supported the establishment of a network of research institutes, scientific societies, and professional organizations connected with basic research, while the bailiwick of NTO was industrial research and development, with administrations for major sectors of the economy. Dzerzhinski joined Lenin in recognizing the need for the help of bourgeois specialists. He supported their autonomy through his work in NTO, and he determined that "specialist baiting"—class-based interference with crucial research and management endeavors—was an act of terror.

Yet throughout the late 1920s and especially with Stalin's rise to power, many officials criticized scientists and engineers for being "divorced from practice," that is, not paying sufficient attention to research with immediate application. Scientists meanwhile criticized bureaucrats and party activists for failing to understand that scientists themselves would best determine the direction of research. Still, the existence of national bureaucracies to support science and technology distinguished the USSR from the United States, Germany, and other countries where no national organization existed to coordinate the funding and organization of research or express the state's policy interests. Glavnauka and NTO were subjugated to the Commissariat of Heavy Industry under Stalin in the 1930s, a move that reflected his view that scientific research must be linked directly to industrial production.

Trotsky recognized the need to rely on bourgeois specialists to develop industry, at least until such time that a new proletarian specialist had been trained. While the Soviets had significant success in literacy campaigns, the revolution had destroyed the system of professional education that had been created under

capitalism, so that they lacked the "professionally-trained worker" who was a "critical lever" in the current economic situation.[38] The Bolsheviks had to rely on the scientific intelligentsia of the old order, whom they would require to focus on questions of importance to the proletariat. Trotsky insisted that specialists must orient "their attention, interests, and their efforts to problems and demands of the new social order." Scientists would carry out the task of overcoming the "horrible backwardness" of the nation, not "in the interests of a privileged minority, but in the name of the material and spiritual growth of the entire people, with the inclusion of the most heavily backward peasant strata." Since the time of Peter the Great, Russia had attempted to raise the cultural level of the nation through western science, but, Trotsky asserted, Peter had not opened a "window" on European culture 200 years ago, only a tiny "porthole" that had served the upper classes while leaving the masses behind.[39]

Socialist Nature Reorganized as a Conveyor

Like other Russian Marxists, Leon Trotsky believed in the power of modern technology to liberate the worker, and he believed that Russia needed to master specifically American technology as the world's most advanced. After Stalin defeated Trotsky in the battle to succeed Lenin as party leader, Trotsky was increasingly marginalized, then exiled, finally forced to leave the USSR, and murdered in Mexico in 1940 by Stalin's agents. On his way out of favor, Trotsky occupied a series of less important positions in the bureaucracy, for example, the Scientific Technical Department; such other rivals of Stalin as Nikolai Bukharin were also pushed into NTO as demotion from the power struggle. Trotsky wrote extensively about technology and politics in the 1920s, although his views on this topic are scarcely known. This is because, after his defeat by Stalin, he was systematically written out of Soviet history, even excised from photographs. Yet his views on technology were instrumental in the formation of many Soviet policies or in triggering debates about those policies. He was certain that capitalist technology would serve the working class, and absent the Bluetooth he employed the locomotive, printing press, radio, film projector, and poster. He was an Americanist in his admiration for the conveyor belt, standardization, and mass production.

Trotsky believed that socialism enabled science to achieve its full potentialities only when it was "nationalized, emancipated from the internecine wars of private property and no longer required to lend itself to the corruption of indi-

vidual proprietors but to serve the economic development of the nation as a whole." The Revolution of October 1917 was a mortal blow to backwardness, enabling the entire people to rise up on the achievements of science and technology. Trotsky wrote that "socialist construction is in its very essence conscious planned construction which concentrates technology, science and well-articulated social forms and methods of their utilization on a scale unprecedented earlier."[40] He characterized socialist construction as "the aspiration to rationalize human relations, that is, subordinate them to reason, that is, arm them with science."[41] The network of research institutes being established by the state was a small "material indication" of the "limitless possibilities" before society. On top of the elimination of greed from social relations, state sponsorship of science and technology would ensure that no revolution was necessary in the transition from socialism to communism since the transition depended wholly "upon the technical progress of society."[42]

Trotsky turned to Marxism in his early years, joined the Russian Social Democratic Labor Party, worked on the newspaper *Iskra* (*Spark*) with Lenin, and became a member of the Mensheviks and then chair of the Petersburg Soviet during the failed Revolution of 1905, spending much of the next twelve years abroad. He returned to Russia in 1917 to join Lenin in rallying the Bolsheviks to victory as chair of the Military Revolutionary Committee. More than any other Bolshevik, except perhaps Lenin, he saved the revolution, heading the Bolshevik delegation in negotiations at Brest-Litovsk in 1918 to secure peace with Germany, serving as Commissar for War (1918–25), creating the Red Army, leading it to victory in the civil war, and working as a member of the Politburo until 1927. In another position as chairman of a commission on the Central Administration of Railways, Tsektran, that was responsible for rebuilding the railroads from world war and then civil war, Trotsky gained firsthand knowledge of the role technology must play in securing the future of the young socialist state. Finally, Trotsky served briefly in the Supreme Economic Council as a member of its collegium and head of three industrial departments—the Concessions Committee, the electrical technical board, and NTO—where he continued to think about the place of technology in revolutionary Russia.

The experience as commissar of war and head of Tsektran convinced Trotsky of the need to create a militarized "production atmosphere" by incorporating trade unions directly into the state apparatus. The "militarization of the economy" during War Communism (1918–20) would raise "labor discipline, selflessness and steadfastness." It would facilitate the struggle not only with interventionists, whites, and monarchists but with "hunger, cold and epidemics." Red Army troops, together with "the best elements of the local proletariat in a given territory," would defend to the death such strategic sites as mines and the territory surrounding them.[43] Trotsky treated each economic crisis he encountered on the war front that delayed the establishment of the dictatorship of the proletariat as one that could be treated through military organization, whether raising labor discipline, increasing the supply of food and fuel, repairing engines, or resurrecting transport and industry from the Don coal basin (Donbas) to the Ural Mountain region.[44]

Trotsky carefully studied the history of technology even before the Bolshevik seizure of power forced him to consider what socialism might borrow from capitalism and address directly how socialist industrial, agricultural, and military technologies might differ from those under capitalism. The miserable performance of the Imperial Army during the Russo-Japanese War in 1904–5 triggered this interest. The Russian Army as of 1904 had not really been involved in military campaigns since 1878. The war showed that it lagged technologically and in the training of soldiers. A great gulf existed between officials and soldiers, many of whom were one generation from the countryside. As Heyman points out, along with other socialists and Marxists, Trotsky had always hated the military for its role in quelling civil disturbances. He despised the chauvinism of the military campaign against the Japanese and the exploitation of the worker-soldier. Yet in various failed mutinies, he noted that skilled military leadership eventually overcame radicals' enthusiasm for revolt. Military discipline was the bourgeoisie's advantage, and he hoped that revolutionary industrialization in Russia would mean that increasing numbers of workers would enter the military and take control of it from within.[45]

As in other areas of the economy, the capitalists had industrialized war. Trotsky observed that there wasn't a great difference between capitalist and socialist countries in the sphere of industry, nor in the quality of their cannons and shells, but in the capacity to produce huge quantities for the duration of the war.[46] The Great War "threw into motion all that military technology which . . . militarism skimmed off, like cream, from capitalist development. And Europe endured. How many times was it said that the newest technology would make war absurd and make it impossible? This hasn't happened."[47] When war broke out in Russia, Trotsky considered the impact of mass mobilization on a backward, feudal country, anticipating that social tensions would bring the autocracy down. The Russian war turned Trotsky's attention to military issues

and affairs, away from social and political questions, even as he recognized that the failure of the Russian army to perform well was the problem of a peasant army run by upper class officers, not only Russia's great technological lag. The technology of war was always getting more advanced, by which he meant more industrial. Yet the principles of "military art" had not changed.[48]

As commissar of war, Trotsky commandeered a special armored locomotive replete with printing press, telegraph, telephone, and movie cameras to record his exploits for propaganda purposes, to print newspapers, and to stay in contact with battle leaders to strike quickly as needed along the front. For two and half years, as he explained in *My Life*, he lived in his heavily armored train with two engines. During this time, the Red Army grew from 800,000 to 3,000,000 and fought on sixteen fronts simultaneously. With his speeches Trotsky stirred up villagers, illiterate peasants, and troops, all of whom were often cut off from news. Through his travel from front to front, from the central industrial region to the Ural Mountain region and to the Donbas, the latter two the crucial mining and metallurgical centers of the country, Trotsky became acquainted firsthand with the country's critical technological weaknesses, and first of all with the ruination of the transport system that had left the city isolated from the countryside, without food and fuel. What little equipment and machinery the Bolsheviks had nationalized when they seized power was outdated, and what little they actually controlled was in need of repair or simply ruined by years of war, especially steam engines. Nothing could be achieved without repair of transport and engines. He proclaimed, "Proletariat, to the machine tools, proletariat, to production!"[49]

Trotsky realized that science and technology reflected the politics and values of the ruling class. He noted that "technique and science have their own logic—the logic of the cognition of nature and the mastering of it in the interests of man. But technique and science develop not in a vacuum but in human society, which consists of classes. The ruling class, the possessing class, controls technique and through it controls nature. Technique in itself cannot be called either militaristic or pacifistic. In a society in which the ruling class is militaristic, technique is in the service of militarism."[50] Similarly, technique and science undermined superstition and religion but also abetted it. Anticipating the persistent attack of modern science by religious fundamentalists into the twenty-first century in the United States, he noted that radio broadcasts of church sermons meant that the radio could serve to spread prejudice. In the Soviet Union, since it was controlled by the vanguard of the proletariat, it would summon the masses to victory: "We have guaranteed the victory over poverty and superstition by advancing technology forward! We cannot lag behind other countries. The first and basic slogan which should be anchored in the consciousness of every friend of the radio: don't lag behind!"[51]

The solution was for the USSR to surpass the advanced countries in the high culture of modern technology. Because of its Tsarist Russian inheritance, the USSR was "extraordinarily backward in relation to the advanced capitalist countries." Given that the capitalist countries continually moved ahead, did this mean that the USSR would always lag and risk being crushed? Trotsky pointed out that capitalism had entered a period of final decay, a blind alley, while the USSR had liberated man's potentialities through new organizational forms, including the planned development of science and technology. But he urged his comrades to remember that "the material accumulations of technique, i.e., not that technique which exists in men's heads, but that which is embodied in machinery, factories, mills, railways, telegraphic and telephone services and so on, here above all else it is clear that we are fearfully backward." He therefore urged his country to focus precisely on communications: steamships, postal services, radio, the telegraph and the telephone, and railroads.[52]

Widespread, inexpensive access to telephones in twenty-first century Russia that extends to all regions of tundra and taiga represents a stunning turnaround from the Soviet era, when phone service was miserable on all counts (and is also a shock to Americans given the spotty and costly service U.S. cell phone companies provide). It took years for a citizen to get service unless he or she was a member of the elite. Calls required tremendous lung power; customers often had to scream into the receiver to be heard across town let alone in long-distance calls, a phenomenon that led to the joke, "Vanya, why not just open the window to yell. You'll be heard just as well in Rostov." In 1917 the nation had about 240,000 telephones versus 700,000 for Britain. While in Europe and the United States telephone service expanded as a matter of course in the early twentieth century, in the USSR it actually shrank in the 1920s for both reasons of technology and reasons of service, in spite of the fact that the Bolsheviks and Lenin in particular understood the importance of controlling the telegraph, the telephone, and the postal service.[53] The civil war and growing significant shortages of labor and capital led the Bolsheviks to order volume of telephone communications cut, with the remaining capacity serving essentially governmental and economic services. This led to communalization of phone service for citizens. During the New Economic Policy, the authorities likely deliberately suppressed

service to prevent unmonitored horizontal communications, at the same time learning to monitor conversation. Another reason for the shrinking of phone service was that the Commissariat of Heavy Industry had limited budgets and other obligations, so it dumped unprofitable telephone exchanges on local government that had even fewer resources; this stifled development for the long term. The suppression of numbers of subscribers was surprising given that both Lenin and Trotsky believed that communications and transport technologies would help create that all-important *smychka* (the economic and cultural connection between city and countryside).[54]

Spotty and poorly funded service was particularly pronounced in regions far off the beaten path. Poor telegraph, telephone, and postal functions in the Russian north indicated the scope of the problem. How could the Bolsheviks establish industries, collective farms, and other enterprises; monitor their operation; and ensure public safety and emergency care when many of these organizations did not have telephones until the 1960s? Regional officials, managers, medical personnel, and others recognized the role that phones would play in promoting economic growth, political control, public health (emergency medical service), and so on. Unfortunately, precisely low population densities and great distances convinced planners that limited investment funds might better be used in other sectors of the economy, notably in heavy industry. Officials also worried about their ability to control information. Hence, they supported the growth of telephone service in larger cities and made phone numbers available largely to well-placed individuals.

Yet even being designated a priority was no guarantee of success. For example, in the mid-1930s officials of the Arkhangelsk Automatic Telephone Station had to exert great pressure on the "Sevkabel" factory to produce telephone line after years of unfulfilled production promises. Sevkabel production of telephone line reached 24 kilometers in September, 39 kilometers in October, and 35 kilometers in November 1935. Soon they would have 3,000 customers in this important city of lumber, fish, and shipping, which would also serve as a Bolshevik beachhead of political control—but only if the Krasnaia Zaria (Red Dawn) factory manufactured phones.[55] Nikita Khrushchev's greater openness and desire to invest in the consumer sector led to rapid expansion of service in the 1950s and 1960s. Still, investment in this sector was one-third the level of that in the United States, and long-distance service lagged two to three decades behind that in the United States in 1970. The alternative to home phone service was to place calls through the local post office. Citizens usually had to wait an

hour or longer to get a connection, meaning that on average the citizen had only two conversations per capita annually. Industrial enterprises dominated phone service. As of 1970, residences had roughly half of the nation's phones, with only 14 percent of telephones in villages, mostly concentrated at collective farms.[56]

Bringing the City and Countryside Together: *Smychka*

One of the major challenges to the modernization of Russia that had baffled the nation's intelligentsia and its enlightened leaders was the backwardness of the Russian peasant, his outmoded agriculture, his lack of awareness of any world beyond the farthest fields, and the absence of any sense of civic culture.[57] Trotsky, too, believed that the low level of economic and cultural development of the *narod* (Volk or "people") created the main obstacles to building a modern socialist economy. This reflected the cultural and economic lag between the city and the countryside in all ways: the worldview of villagers, the poverty of their lives, their low labor productivity. Trotsky saw modern technologies as the way to bridge the gap between the city and the village, what came to be called the establishment of *smychka*, a link between them, between the proletariat and the peasant, the new and the old, the modern and the outdated. At the end of War Communism and during the New Economic Policy (NEP), Trotsky addressed the importance of the establishment of *smychka* in a series of publications and speeches, with various technologies serving as emissaries of cultural change.

The Soviet empire stretched from Europe to the Pacific Ocean and from the Arctic Ocean to Central Asia. Toward the ends of modernization, and of control over space, time, people, and resources in the vast empire, the Bolsheviks sought to impose industrial forms and organizations on what they considered to be an outdated, irrational way of life, on people, and on nature itself. They had to simultaneously impose new, modern ways of surveying, tabulating, arranging, organizing, and manipulating resources and people and employ vigorous methods of overwhelming local ways of seeing the world. As Scott describes it, the Bolsheviks needed to see this vast space like a state, using modern science to collect aggregated and accurate data.[58] Trotsky provided several examples of the peasant's outdated and inaccurate view of the world that needed to be overcome. If you asked a peasant how many versts (a little over a kilometer) it was to the village of Ivashkova, Trotsky wrote, he'll tell you three, while it might be seven or eight. As war commissar, Trotsky had encountered an arbitrary and inexact attitude to space and time that inhibited proper military action no less than it

inhibited modernization of the countryside. When he ordered artillery to a critical engagement, he had to hope for modern roads and capable soldiers who understood space, time, and trajectories. Trotsky granted that the peasant of the 1920s, the peasant who embraced the tractor, was not the same peasant he had been in 1861 after emancipation, nor who he was on the eve of World War I. His conditions of life and consciousness had experienced great change. Yet the continued problem of the peasant's outmoded way of thinking would be heightened during pursuit of socialist construction because "industry, machine production, by its very nature demands exactness." A wooden plow may turn soil this way or that, but if the teeth of a wheel did not mesh precisely with the gears, "the entire machine will stop running or break." Peasants needed to learn how to operate machinery properly. Similarly, the machine would bring about a change in peasant worldview. Trotsky wrote, "Only broad development of machine economy, the proper disposition of labor and its correct organization will train the habits of exactness and accuracy."[59]

Trotsky was not worried about the fact that the first steps of socialist development occurred on the foundation of the technology, culture, and other remnants of the old regime. Political revolution ensured the proper direction of further development. Yet, while the Bolsheviks had taken great steps forward in securing political power, they had fallen short elsewhere, especially in the economy, agriculture, and technology. For example, electrification had moved ahead on an old path: first of all, on the programs of engineers from the old regime, and second, on peat, not on oil power. A successful national electrification program required not only advanced technology but the training of new engineers, technologists, and workers, with rural teachers leading the way in rural schools by propagandizing the virtues of modern technology, and with advanced research at such central institutes as the Timiriazev Agronomy Institute. This, in turn, Trotsky argued, would facilitate the penetration of advanced machinery and equipment into agriculture and enable agronomists to bring the latest discoveries to the peasant, with better harvests as the result.[60]

Trotsky believed simply that industrialization of agriculture, a central feature of socialist construction, would end the contradictions between the city and countryside, between the peasant and the worker. He envisioned a society "where mechanized field-crop cultivation makes up an equal part of planned economy, where the city absorbs the advantages of the countryside (its expanses and greenery), and the countryside will become enriched by the advantages of the city (paved roads, electrical illumination, plumbing and sewage)."[61] The

modern, highly productive peasant would begin to think about the sale of surplus at distant markets. In general, socialist industry would thrive with the establishment of *smychka*, with raw materials from the countryside going to cities, and with tools, machines, and electrical energy going to the village. Socialist industry would produce the miracle of "mechanization of agriculture." Trotsky offered this metaphor for the socialist technological revolution in the countryside: "Every tractor is a small tugboat of industry that is charged with pushing the peasant economy out of the swamp of the open-field system[62] and thoughtless wasteful labor." He continued, "The tractor is not only technological, but also a cultural tugboat."[63] As noted, the Soviet Union imported thousands of these "tugboats" in the 1920s, using them to force the pace of industrialization of agriculture and transformation of the peasant worldview. The fact that most of them would be imported did not trouble Trotsky since the tractor could serve its capitalist masters to exploit the agricultural worker, or its socialist peasant to produce surplus of benefit to all.[64]

Modern technologies of transport were the final component of the technological revolution needed in socialist Russia. Trotsky noted that by all indices—total length, kilometer/tons of freight, and so on—Russia was far behind the United States and Europe; the United States had almost 6 times more railway than the USSR.[65] He wrote, "Our huge space without the railroad reminds us, first of all, of our extreme economic and cultural lag. Railroads—are the communication connections of the country, they are the channel of the cultural influence of the city on the countryside." Yet technology required socialist comprehension and application. Without Bolshevik leadership, the railroad could not fulfill its manifest goal. And if the railroad connected the empire's immense spaces from cultural and economic points of view, then from the point of view of politics the Bolshevik played "the same role that the railroads play in relation to our spaces. This—is the connection, this is *smychka*, this is the path of the cultural influence of the capital on the province, the province on the district, the district on the region and so on lower and lower."[66]

In a speech at the opening of the first All-Union Congress of the Society of Friends of the Radio on March 1, 1926, Trotsky referred to the way that radio established *smychka* with Turkmenistan, a republic larger than any European country, whose inhabitants lived in isolated oases. In the absence of roads and railroads, radio facilitated the first steps of socialism. Trotsky observed that three-quarters of rural inhabitants did not know what a radio was, and that the other quarter knew only because of isolated Bolshevik demonstrations of this

modern miracle. Yet he ridiculed skeptics for doubting the ability of the Soviets to use radio toward socialist ends, or in general to use the latest achievements of science and technology in ways impossible under capitalism. He asked skeptics to consider the fact that within the last twenty-five years the automobile, the airplane, the phonograph, and the tractor had changed the world before their very eyes.[67]

The railroad would facilitate the next steps of modernization in backward Turkmenistan. An early hero project, the Turksib (Turkestano-Siberian) Railway, a "firstborn of the Five Year Plan," was intended to link the grain-surplus areas of Siberia with the grain-deficit but cotton-rich territory of Turkmenistan. Viktor Turin's documentary film, *Turksib* (1931), captures the enthusiasm of the workers who successfully built a railway 1,440 kilometers in length from Frunze in Turkmenistan to Semipalatinsk in Kazakhstan, through some of the most inhospitable and desolate landscapes in the world.[68] In *Turksib* technology plays a glorious role, unlike that, according to Pare Lorentz, who produced the film *The Plow That Broke the Plain* (1936), where modern agricultural technology creates the Dust Bowl in the Great Plains states in the 1930s. Yet while leaders saw technology as a tool to build socialism, to establish *smychka*, to develop resources, to train workers, and to modernize Central Asian peoples, the local Kazakh workers were treated as backward, unskilled, and unequal in spite of their contribution to the project.

For Trotsky, the leading technology, and therefore the highest form of culture, was the Fordist system of mass production based on the conveyor. Trotsky observed that the principle of socialist economy was harmony. Technologically, harmony found "its highest expression in the conveyor . . . Now it is generally known how Ford uses a combination of conveyors as a means for internal transport: transmission and supply." He continued, "Socialist organization of the economy should strive to remove the physiological burden of the individual worker" through the conveyor and "secure technical agreement with other workers."[69] He was so enamored of conveyors that he saw modern hydroelectric facilities as "gigantic melioration systems—water conveyors of agriculture." Once modern fertilizers, modern machines, and electricity made it to the countryside, "the more completely will our present agriculture be included in the system of the socialist conveyor."[70] Trotsky was overjoyed at the prospect of large-scale enterprises, standardization of production, specialization of firms, and transformation of entire industrial plants into mighty consolidated "works," apparently having in mind such facilities as Henry Ford's River Rouge factory.[71]

Standardization would achieve full success in socialism where it would be facilitated by the "true nationalization of the scientific-technical knowledge" and centralized planning. Instead of each purchaser having "to improvise and grope around," he instead had access to finished samples best representing his needs as a result of scientific investigation.[72]

Trotsky's willingness to force workers to employ military techniques to raise industrial production and his effort to impose on the entire nation every advanced industrial, communications, and transport technology to overcome spatial, temporal, and ideological distance between city and countryside indicate limited understanding of nascent environmentalism in Soviet Russia. In Trotsky's view, both people and nature had to conform to the desiderata of modern technology. A movement to create a network of nature preserves (*zapovedniki*) gained momentum in the 1920s, although it faltered gravely under Joseph Stalin and Nikita Khrushchev, who saw mainly economic value in exploitation of nature.[73] Trotsky supported the establishment of *zapovedniki* but was impatient with the capriciousness of nature. He seems to have called directly for the subjugation of nature. In an essay entitled "Literature and Revolution" (1924) he wrote the following:

> The present distribution of mountains and rivers, of fields, of meadows and steppes, of forests, and of seashores, cannot be considered final. Man has already made changes in the map of nature that are not few nor insignificant. But they are mere pupils' practice in comparison with what is coming. Faith merely promises to move mountains; but technology, which takes nothing "on faith," is actually able to cut down mountains and move them . . . in the future this will be done on an immeasurably larger scale, according to a general industrial and artistic plan. Man will occupy himself with re-registering mountains and rivers, and will earnestly and repeatedly make improvements in nature. In the end, he will have rebuilt the earth, if not in his own image, at least according to his own taste. We have not the slightest fear that this taste will be bad.[74]

Taken with his other writings on electrification, industry, the establishment of *smychka*, and so on, Trotsky was well within the Bolshevik mainstream of party officials and engineers who believed that the productive forces must be developed at breakneck speed, regardless of the environmental costs. He also shared the prevailing view of officials and engineers in other countries. Like their counterparts in the U.S. Army Corps of Engineers and Bureau of Reclamation, Soviet engineers with various construction trusts and engineering orga-

nizations hated swamps, despised meandering rivers, and detested the flow of water downstream without using it for a variety of municipal, agricultural, or industrial purposes. Bodies of water were meant to have utility year round; wastelands were meant to be gardens. Whether Turkmenistan or the Plains states, nature must be made beholden to the state.[75]

Trotsky, Lenin, and others believed that at least a generation was required to raise the level of culture of the peasantry. The NEP, passed at the Tenth Party Congress in 1921 to jump-start the socialist economy with small-scale private businesses, was a breathing space, a time for the "assimilation of the simplest information, knowledge, methods and habits." Shortly, modernization would occur along "socialist rails."[76] Trotsky discounted the fear that the USSR would always play technological catch-up behind the advanced western nations if it relied on capitalist institutions and technologies. But "never forget," Trotsky wrote, "that the work of scientific-technical thought in bourgeois society has achieved its full flowering in such a period when the economy of bourgeois society all the more falls into a blind alley and rots. The European economy will not go forward. Europe in the last fifteen years became poorer not richer. And it has had colossal inventions and discoveries."[77] The question was rather how to overcome backwardness in the USSR. "What will transform the country into a unitary economic and cultural whole?" Trotsky asked. His answer? Technology. He called for significantly greater expenses on post, telegraph, telephone, and other technologies to bridge the great space and time of the Soviet empire. Only technology would create *smychka*. Trotsky wrote, "Developed socialism signifies first of all the technological and cultural equivalence of the city and the countryside." Ultimately, the fusing of city and countryside was "a question of life and death."[78]

Technology Decides Everything, or Technology Masters Us

So long as Leninist attitudes toward the specialists prevailed, scientists and engineers retained a good deal of autonomy, and the efforts of such leftist groups as the Workers' Opposition, who found Lenin's position to be pandering to specialists at the expense of the proletariat who really ought to rule, and militant communists were blunted. After Lenin's death, tensions grew between party officials, responsible for seeing the resurrection of industry destroyed during World War I, revolution, and civil war, and scientists and engineers, who had become used to a modicum of freedom in establishing research directions in

newly founded institutes. Pressure grew for them to produce technologies, techniques, and processes that served the state and the proletariat directly. During the industrialization campaign of the 1930s, this unrelenting pressure forced many of them to toe the line to production and turn to narrow technical subjects. Otherwise, they risked facing accusations that they engaged in "ivory tower reasoning" divorced from the needs of the working class. Still, such Bolshevik industrial leaders as Valarian Kuibyshev and Sergei Kirov defended the engineers against the most demeaning of these demands, although suggesting that they could do more for the national economy.[79]

During the NEP, Stalin warned of the need to build socialist industry in the coming years so that the nation would not become an appendage of capitalism, but rather an independent economy that relied mainly on an internal market and on *smychka* between industry and the peasant economy.[80] Although the nation had reached prewar levels of production by 1926, it remained agrarian. The next steps of the unfolding of socialist industry on the basis of advanced technology demanded great capital investment, and its lack meant that future growth would be only at the tempo of recovery. Yet in 1926 Stalin did not yet insist on rapid industrialization, but he called for investment in local industry to satisfy the people in each region, province, and republic, because without support of local industry there could be no *smychka*. Stalin referred to Lenin, not Trotsky, to justify this moderate view.[81]

In 1923 Georgii Piatakov, the deputy chairman of the Supreme Economic Council who had been involved in the resurrection of the Donbas coal industry and also worked in Gosplan (the State Planning Administration), tried to dissolve NTO and place each research organization directly under the industrial trust for which it worked. This would have tied research tightly to pressures for immediate application. But the chemist Vladimir Ipatieff, a patriot who had served Tsarist and now Bolshevik science, but eventually emigrated to the United States in 1931 over the increasing restrictions on his life and work, joined other scientists in convincing Bukharin, Trotsky, Dzerzhinski, and other party officials of the view that, inevitably, research would in all events lead to myriad applications for the benefit of the proletariat.[82] As noted, on their way out of political favor, both Trotsky and Bukharin were demoted to service as chairmen of NTO, a move that suggests how much respect for scientific autonomy had fallen since the death of Lenin. From this position Bukharin pushed for planning of science to ensure the proper level of funding, geographical distribution, presence of well-trained specialists, contributions to the economy,

and an end of "ivory-tower reasoning."[83] However, the relatively poor record of NTO institutes in producing these applications, as well as the rise of communist bureaucrats who were impatient for results, led to the expulsion of Ipatieff and others from NTO. Subsequent NTO directors emphasized economic concerns and hoped to improve industrial performance by linking it to research.

Yet, NTO leadership still far from embraced the mercenary, mechanical view of science and technology that ultimately prevailed under Stalin. In the late 1920s, when Bolshevik leaders debated when to end the NEP and how rapidly to pursue industrialization, Kuibyshev, a major industrialist, and also head of NTO and later of Gosplan, fought to protect the autonomy of scientists and engineers.[84] He opposed Stalin's determination to bring specialists to heel through a series of show trials and other pressures, and he also defended autonomy for factory managers, recognizing that they might be an important source of innovation. He called for factory managers to be given flexibility in the formulation of plans and fulfillment of targets through "decentralization of operative activity." He wrote, "Real people who are building our industry, to whom this matter is near and dear, should not be deprived of initiative which may facilitate and will of course facilitate the development of industry."[85]

In a speech at the first All-Union conference on professional and technical education in September 1927, Kuibyshev urged acceleration in the training of large numbers of engineers to meet the growing challenges facing industry. Soviet engineers were not only few in number but also poorly trained. One of those challenges was "a lack of preparation when our personnel order equipment abroad for our industry." He declared, "We do not know the newest achievements of technology, and we do not know how properly to indicate specifications. Our technical thought is poorly tied to new production." This was a serious problem given that American innovations frequently "change the entire picture of industry."[86] Kuibyshev constantly urged the study and assimilation of western technology and consideration of how most quickly to master European and American achievements as crucial to the needs of socialist construction during the first five-year plan, not the short-sighted rejection of them.[87]

Like Trotsky, Kuibyshev was enamored of the assembly line and believed that it was essential for Soviet industry to adopt modern mass production techniques rapidly. In the journal *Standart* Kuibyshev published an article in 1931 in which he argued that the problem of quality control in industry could be solved through the application of centrally determined production standards. He wrote that only the USSR had propitious conditions for the further development of standardization. Under capitalism, different firms meant different standards that led to waste and duplication of effort, while in the USSR the central authorities could legally set national standards, order them throughout a corresponding branch of industry, and standardize on a much larger scale. Kuibyshev blamed the poor results in standardization on the factory manager who did not yet understand the relationship between his responsibilities and national programs.[88] The fascination with centrally determined standards found constant expression in technologies across the nations of East Central Europe (chapter 2).

Sergei Kirov, the Leningrad Party chairman until his murder in 1934 at Stalin's behest to eliminate this potential rival, began his party career in the Caucasus in political and military work, but he preferred agitation. He frequently visited Leningrad's major factories—Elektrosila, Bolshevik, Krasnyi Putilovets (known for its locomotives and its copies of the Fordson tractor), Red Nail-Maker, and others—to propagandize higher production and to celebrate the production of ingots, turbines, tractors, and no doubt nails. (He also spoke about the glories of the victory of Stalin over Trotsky and Zinoviev in the struggle to carry Lenin's mantle; later, he developed doubts about Stalin's leadership, but his murder prevents us from gauging the depth of his concerns about him.)

Kirov directly engaged modern science and technology. He pushed the expansion of hydroelectricity through GOELRO, in December 1926 praising the opening of the Volkhovskaia Hydroelectric Power Station. The Volkhovsk station, whose Bauhaus-like machine hall is visible to this day from trains out of Petersburg going north to Karelia, had symbolic and economic significance. The travails of its construction also reveal the epic obstacles the Bolsheviks would continue to encounter at every work site of building socialist industry. Lenin himself joined GOELRO engineers in approving the construction of this station, although he died before its completion in 1926. In virtually every discussion of the history of hydroelectricity, Soviet authors mention the station as the first "brilliant" step on the path to electrification. The station fostered regional development in Leningrad Province, including ultimately stimulating another "first": another resource-intensive facility, a factory that produced the first aluminum ingots of Soviet power in 1934.

Many of the Bolshevik hero projects had prerevolutionary roots. Scientists and engineers who fantasized about magnificent central electrical power stations and canal, lock, irrigation, reclamation, railroad, road, and bridge projects to end the scourges of drought and famine and to bring Russian industry into the twentieth century now had partners in the Bolsheviks, especially Lenin and

Trotsky. The engineer in charge of Volkhovstroi, Count G. O. Graftiiu, had published a series of articles in such journals as *Elektrichestvo* on a Volkhovsk project before the revolution, and he gave a speech to the Society of Electrical Engineers on the eve of World War I proclaiming its importance to the future of the nation. Bolshevik officials approved the project on May 26, 1918, just as civil war broke out.[89] The project moved forward slowly and manually, taking years longer than a peacetime project might take. Site conditions were the major reason for the slow pace. Men armed with pikes, picks, hammers, and sledgehammers felled trees, gathered boulders, built caissons, and laid rail. They lived in barracks and mud. In the absence of domestic sources, Volkhovsk engineers turned to the Swedish firm Nydqvist och Holm AB (NOHAB) for ten turbines and Allmänna Svenska Elektriska Aktiebolaget (ASEA) for four generators since Soviet industry could not manufacture them. In 1920 NOHAB received an order from the Soviet government for 1,000 steam locomotives, which was later cut to 500 owing to political uncertainties; these were delivered between September 1921 and December 1924 and paid for by fifty-six tons of gold.[90]

Officials always announced the next hero project as the first, the largest, the fastest built, the most progressive, or the one that excavated the most earth and poured the most concrete. Indeed, for the very first technological feat, the "child of Lenin," the Volkhovsk hydroelectric power station, officials touted its glories, although when completed it usually ran at half of its capacity. Workers and engineers joined hands to build the station during "the darkest pages of history of revolution" when they had literally nothing, "neither iron, nor brick, nor excavators, nor tools, nor even nails." Officials made the project a priority, requisitioning what they might from as far away as Siberia. Here they scrounged up some flywheels and ingots to resmelt, and there they scoured the country for timber, steel, cement, wires, motors, and bread to feed the workers. Construction dragged on for over five years, consuming 16,000 tons of iron, 80,000 tons of cement, 5 million bricks, and 40,000 cubic meters of stone.[91] Yet officials concluded that this was worth the expense and effort in order to honor the memory of Lenin, and because the construction site served the ends of both employment and training unskilled workers on the fly.

Already experiencing the kinds of spoken and unspoken pressures that prevailed in the Stalin era, engineers learned on the job much of what they ought to have studied before commencing such a large-scale project. Before sinking a shovel, they should have considered thoroughly the river's hydrology, currents, annual and seasonal flow, soil, and geology. Yet their enthusiasm to embark on

grandiose nature transformation projects—and under Stalin the unyielding pressure to finish the projects—often led them belatedly to consider important physical and technical details. At Volkhovstroi, the engineers established a working group of hydrologists to focus on the "ice tyrant" (ice formation, ice flows, and so on) only in 1924, years into the project. Because of the poverty of the project, the haphazard nature of securing machinery, equipment, and supplies, and the high learning curve of engineers and workers alike, Volkhovstroi transmitted power to Leningrad only in December 1926 and as late as 1928 operated at only 64 percent power.[92] At its dedication, Sergei Kirov, by then secretary of the Leningrad Party organization, declared, "Leningrad workers today celebrate a new victory, but to us [the Volkhov station] already means very little. We are obligated to move forward and on the experience of Volkhov to build more powerful stations. We must learn to build so that we can escape the need to buy equipment abroad. Our government is doing all it can so that everything—from the first brick to the complex machines—is manufactured by our own hands in our factories. And we will achieve this."[93]

Kirov was involved in the establishment of the USSR's first aluminum plant, powered by the Volkhovsk station. Military officials love aluminum for its strength, light weight, and flexibility. Aluminum requires a great deal of electricity to produce. Many major hydroelectric power stations produce copious amounts of inexpensive electricity, and many of them were brought on line before consumer demand warranted the construction of such large stations, for example, on the Angara River in Siberia, on the Columbia River in Washington State, in the Tennessee Valley, and along the Sao Francisco, Tocantins, and other rivers in Brazil. In each case it was built to serve the masses, and yet in each case the lion's share of electricity went to industry, industry of importance to the state, and not only aluminum production but often uranium and plutonium production for nuclear weapons. Volkhovsk became such a site to produce aluminum ingots. Construction on aluminum smelters began in 1930 on the right bank not far from Khalturino where the employees lived. The factory arose again under very difficult conditions—much of the work was manual in the absence of machinery and equipment. Exhorted by political instructors and assisted by French consultants, the workers toiled in mud, rain, and penetrating northern winds, finishing construction in April 1932 and producing the first Soviet aluminum three weeks later. A series of accidents plagued production, and only in 1938 did the plant operate normally.[94]

For Kirov, too, the success of socialist construction depended on overcoming

the obstacles of outdated machinery and outmoded thinking. This would not be an easy task since it required "to resurrect the old factory left by the capitalists, to repair old, rusty machine tools and bring them into operation, or to get this or that furnace that has been standing idle for several years to breathe and fire up . . . and to create on our soil new factories on the latest word of contemporary technology." Kirov urged not a follower's envy of America's great factories, but taking the lead in technological innovation. To build this modern technology required transforming the peasant's worldview. Kirov said, "It is necessary to wean the *muzhik* from praying before Nicholas the Wonderworker . . . so that, not in words but in deeds, he really becomes accustomed to electricity and other such things." He continued, "You cannot give a *muzhik* a tractor and other magnificent tools of production, if he still puts greater hopes in Nicholas the Wonderworker than in, say, an internal combustion engine."[95]

While Kirov welcomed foreign technology as a foundation for Soviet achievements, like other Bolsheviks he began increasingly to worry about the reliability of foreign experts and got caught up in the fervor of the antiwrecking campaign. Might capitalist engineers be in the service of foreign capital? He accused bourgeois specialists in a 1930 speech to the Caucasian regional party committee of sabotage. Kirov asserted that agents of the bourgeoisie and interventionists had penetrated literally every region of the economy, including transport, agriculture, even planning and economic organizations, although, Kirov assured his audience, they were not capable of slowing socialist construction. Still, the Soviets needed the participation of these specialists at Dnieprostroi, the Stalingrad Factory, Magnitostroi, and other hero projects of hydroelectricity, tractor manufacture, and the like. He declared the following:

> You all know what difficulties our new factories give us, our new giants, our new plants. We built the Stalingrad Tractor Factory upon the latest works of European-American technology—this factory has no equal literally in the world. We are insufficiently experienced in technology—in this relation we are still barely literate, but we invited to Stalingrad well-known specialists from around the world, and no matter how difficult it was, we brought the factory on line. Further, we are building the Magnitogorsk giant. And for this we enlisted the best, the well-experienced American engineers, but Magnitostroi for them was a new thing, and together with us they racked their brains. You yourselves understand this wasn't a very easy or simple thing.[96]

Kirov reminded the party faithful of the need to be free from dependence on capitalism. But to be fully emancipated from the West, they needed to create a working-class technical intelligentsia; many factory directors unpatriotically preferred foreign equipment to Soviet technology.[97]

Stalin Wants the *Muzhik* to See Him as the Father of All Technology

Recognized for his crude understandings of politics and society and unsophisticated interpretations of Marxist thought, perhaps Stalin alone among early Bolshevik leaders recognized that technology and science were inherently political, reflecting as they did fundamental beliefs about how nature worked, the human relationship to nature and to the operating economic system, and even epistemological understandings.[98] Technology in and of itself was no longer the key to the Soviet future. Stalin and other militant communists understood that economy and polity shaped technology and thus insisted that the political and economic systems be reformed to reveal the proletarian reality as they comprehended it. When the nation embarked on Stalin's self-proclaimed Great Break (*velikii perelom*) with past party programs, he announced that "Technology will decide everything!" But workers and engineers alike had trouble with this slogan—and with the machines. Within a few years, facing "hostile capitalist encirclement" and a variety of treacherous enemies within the socialist fortress, Stalin declared instead that "Cadres will decide everything!"

Stalin's rise to power fundamentally changed attitudes toward the place of western technology in the USSR. Stalin promoted autarky, at the same time exaggerating the innovativeness of Soviet industry and technology. He insisted on Soviet engineers going their own way, yet he required that they master western achievements through purchase, reverse engineering, and espionage. Stalin was a propagandist who spoke in riddles and myths so that his audience might debate the essence of his meaning. In his early writings he addressed the importance of modern western technology and expertise in socialist construction and in the transformation of agriculture. He gave the impression that he shared Lenin's view that some time would be needed before the peasant had reached a cultural and economic level suitable for collectivization. After he won the struggle with Trotsky, and then Zinoviev, Kamenev, and Bukharin, to succeed Lenin, however, he came to reject the NEP and expressed only impatience with the pace of industrialization and with the intransigent peasant who refused to ally

himself with the Bolsheviks. He was enamored of huge increases in the output of the metallurgical, mining, construction, machine-building, and electrification industries[99] and regarded investments in the consumer, housing, and health care sectors of secondary importance. The Stalinist plan for the collectivization of agriculture was intended to extract capital from the countryside for industry, not to create *smychka*; until the collapse of the USSR, agriculture remained a sore spot in production, a place of poverty, shortages of consumer goods, inadequate health care provision, and out-migration of young men and women.

At the center of Stalinist development programs stood huge construction projects important for symbolic and ideological reasons as well as technical and economic ones. The authorities concentrated great resources on these projects—the Dniepr hydroelectric power station (DnieproGES in Russian), the Belomor-Baltic Canal, the Magnitogorsk Steel combine, the Moscow Metro—such that even crucial infrastructure of roads, hot and cold water, electricity, and railroads lagged, not to mention even greater lags in housing, schools, hospitals, and stores. Work sites were amorphous concentrations of mud and garbage, sewage and mosquitoes, ice, snow, and wind, tents and barracks, temporary buildings and piles of rubble, rarely with a formal plan for municipal works, let alone roads, buses, and trams to transport workers from home to work—yet with the intense motion of frenzied construction. The Stalinist projects were quantitative leaps in tons excavated and poured, numbers of workers employed, kilowatts of capacity planned, and symbolism of socialist victories achieved. DnieproGES, in the words of popularizers, symbolized victory over rapids that had been "foaming for ages." It was designed for 810,000 horsepower, at the time the largest station in the world. It reflected, as H. G. Wells observed, the switching on of the lights of the "Dreamer in the Kremlin [Lenin]," the "creator and inspirer of the ingenious electric Utopia of Soviet Russia."[100] Yet, technology became technology for Stalin and the state, not for the sake of the worker.

Early urban plans to provide the correct environment for hard work and joyous living were abstract, even unrealistic in design, reflecting ideals of "disurbanized" industrial life, not what was possible given Soviet poverty, backwardness, and the pressures of the leaders to meet superhuman targets ahead of schedule. For example, the first blueprints for Magnitogorsk saw the city organized along narrow ribbons of activity that tied industrial and agricultural regions together and ensured the preservation of green zones.[101] As with other production cities, Magnitogorsk turned out to be an agglomeration of housing, waste, and pollution, centered around smoke-belching industry, a city where

one-third of the adults and two-thirds of the children under fourteen years old have suffered from respiratory infections, and where birth defects doubled from 1980 to 1990 (see chapter 5).[102]

Why did political authorities and planners decide to concentrate resources at a few major construction sites? Why did entire industrial cities come into existence? Was Stalinist coercion the only way to transform the worker's worldview in one generation, in one five-year plan? They were forced to make this choice for several reasons. One was a shortage of resources during nationwide building campaigns that stretched capital and skilled labor resources to the limit. Another was precisely the decision to use construction sites as forums to transform peasants and workers into conscious communist proletarians. A third was recognition of the symbolic value that large-scale projects would serve both at home and abroad to demonstrate the glories of the communist system. A fourth was the opportunity to try out such domestically produced and imported technologies as turbines, tractors, and other earthmovers on the fly while determining how best to employ them throughout the empire. There were two problems with the latter tactic. First, workers often poorly understood how to use them, and frequently the machinery and equipment were damaged at a work site or even rusted as they waited in a field exposed to the elements. Second, engineers sought prematurely to fix parameters for technologies that held across eleven time zones and wide-ranging climate and geography, since they did not have the time or resources to be constantly innovative in the face of plan pressures.

Those pressures grew sinister under Stalin. When party leaders signaled their intention to transform radically the relationship between specialists and the state, it triggered a violent campaign to subjugate the scientific and engineering community to economic development programs. It was directed physically at specialists whose training dated to the Tsarist era and at foreigners, both of whom communists had come to believe were inherently untrustworthy as representatives of the bourgeois social order, and it was directed psychologically at all future specialists. In 1928 and 1930 Soviet prosecutors held two public show trials at which they accused engineers of being wreckers and/or spies on behalf of foreign powers. The trials were the culmination of the so-called Industrial Party Affair and the Shakhty (Mining) Affair. In March 1928 the authorities arrested five German technicians and fifty Soviet engineers involved in installing—and allegedly sabotaging—turbines and mining equipment in the Donbas, accused them of being involved with a fascist organization, and implicated German firms in the affair. The Soviet Union needed western assistance, so this was

a strange charge, all the more so since, at the subsequent show trial in the summer, it was clear that the authorities had orchestrated the trial to the last detail. While the German engineers were released, eleven prisoners received death sentences.[103] For the so-called Industrial Party Affair, during a trial of November–December 1930, the prosecution accused Soviet engineers of having formed anti-Soviet "Union of Engineers' Organizations" with ties to Mensheviks that set out to wreck industry and transport in the preceding four years.[104] For most scientists and engineers the lesson was clear: do not engage in politics, do not fight young party bosses over the appropriate role of scientists in Soviet society, and do not argue with the plan that should take precedence over any scientific consideration of what was rational or possible. Even more, be wary of innovation if it conflicted with short-term plans, and do not audibly praise European or American technology.

One foreign observer commented that the regime treated foreign engineers, its "engaged servants," with fear. They were "perpetually under a cloud of suspicion." According to a Soviet informant, the struggle with specialists was like a pogrom: "Specialists are terrified, much to the detriment of the cause. Frequently they do not venture upon any innovations, to avoid compromising themselves with a failure, but are content to imitate what has been well tried by others," he told the observer. Cultural works heightened the suspicion. Consider Nikolai Pogodin's play *Tempo*, with a run of over two years in Moscow Trade Union Theater, a "comedy" that revolves around bringing a factory up to full power and the relationships between red specialists and foreign specialists—that is, between inherently honest and dishonest people. Through *Tempo* audiences learned that enemies lurked everywhere at every construction site.[105] In *Tempo* the American engineer, Carter, perhaps modeled very loosely on Hugh Cooper, who helped build DnieproGES, notes that Soviet achievements—168 percent overfulfillment of the plan—are "outside the reach of any country with a different political organization from the one existing here."[106] The comedic aspects of the plot may have something to do with the treatment of bumbling "wreckers" and with characterizations of several Russian workers. Carter refers to the workers as "good men, but they do scratch themselves too much . . . Tell them not to be afraid to change their underwear occasionally. Tell them it is already seven and time to start on their work."[107]

Once the industrialization campaign had commenced, Stalin abandoned any pretenses about seeing technology primarily as a tool of liberation for the working class. It had become an instrument of state control, a symbol of state power,

strategically essential to the preservation of the USSR and "socialism in one country." Soviet technology would differ from capitalist technology in its design, organization, speed, and efficiency. Beyond the claim that socialist technology would benefit the entire working class, it is unclear how in reality it differed except in being of simpler rudimentary design. At the same time, Marxist scholars and scientists argued strongly that science under socialism also differed from science under capitalism because only the former was planned and rational and served the masses, not the profit motive; it even had a different methodology. This thinking contributed to the rise of Lysenkoism in biology, a kind of Lamarckian system based on the notion of the inheritance of acquired characteristics that led to the official rejection of genetics in the USSR in 1948.

The belief among Stalin and other communists in a proletarian science and proletarian technology was accompanied by a reevaluation of the basis-superstructure theory that undergirded historical materialism. In many ways, these views resembled those of the discredited *Proletkultists*. Previously, Marxist theorists had argued that the productive forces of capitalism—the means of production, tools, instruments, and likely science itself—clearly continued to operate under socialism, albeit with different productive relations that ensured their service to the working class. As part of the superstructure arising on that capitalist basis, the juridical, legal, philosophical, and other institutions of bourgeois society were destroyed during the revolutionary transition to socialism. Now it seemed that Stalin and his followers saw science *and* technology as part of the superstructure, hence giving rise to the notion of distinct proletarian, or in this case Soviet, technologies and sciences, a view that prevailed until the late 1950s.[108] We see the manifestation of aspects of these ideas in Stalin's pronouncements about industry, technology, and the dangers of wrecking among foreign engineers and their sympathizers.

In a February 1931 speech intended to exhort workers to fulfill the first five-year plan in three years, Stalin indicated that the time had come for the working class to push aside the old experts and "master" technology themselves. For nearly a decade they had allowed old technicians, engineers, and specialists to carry on with production while communists had hesitated to interfere in technique. The communists often limited their involvement in production to observing the old specialists, studying technology, and persevering in learning industrial management, yet they delayed becoming leaders of industry. Stalin recognized that capitalist industry had been an engine of innovation, but he argued that the development of the productive forces under capitalism and fur-

ther rationalization in industry led not to improvements in the standard of living of workers and peasants but to a crisis of overproduction, waste, poverty, and unemployment, as the Great Depression confirmed for attentive Soviet readers.

Further, as the Shakhty and Promparty affairs indicated, this had enabled wreckers and representatives of foreign capital to sabotage the industrialization campaign. Stalin proclaimed that "both the party organizations and the trade unions lacked revolutionary vigilance. It revealed that our industrial managers were monstrously backward technically, that certain old engineers and technicians, because of the absence of any control, were so much more easily being drawn into wrecking activities." He continued, "It is time, high time, to turn our face to technology. It is high time to . . . become specialists, business experts, we must ourselves become full-fledged managers of our affairs."[109] The working class had to master technique, acquire science, and refuse to slow down, fall further behind, and allow Russia to be backward. They had to adopt "a truly Bolshevik pace in the building of our Socialist economy." Stalin continued, "We lag behind the leading countries by fifty to 100 years. We must close this distance in ten years. Either we do this or they will crush us."[110] In a well-known injunction to his audience he called for the Bolsheviks to "master technology. It is time for the Bolsheviks themselves to become specialists. Technology in the period of reconstruction decides everything . . . They say that it's difficult to master technology. This is untrue! There are no fortresses which the Bolsheviks cannot conquer!"[111]

Stalin called for the development of socialist industry at rates that no capitalist country had achieved and for "reaching and surpassing" capitalist nations in short order.[112] During the first and second five-year plans, the USSR indeed made tremendous strides in the creation of indigenous heavy industry. Granted, the country met very few of the overly ambitious targets, and officials published false statistics to indicate success. Yet, as Stalin informed the nation, the USSR had undergone an industrial revolution in a few short years: they had had no nonferrous metallurgy, now they did; no tractor, automobile, machine-building, chemical, or aviation industries, and now they did. They produced electrical energy and petrochemicals among the world leaders.[113] But they had discovered that technology was not the panacea they anticipated.

Would Trotsky Wear a Bluetooth?

The Russian Revolution unleashed unbridled enthusiasm for all things technological. Not only Bolshevik leaders but such representatives of the artistic and educational worlds as proletarian writers imagined a world of magnificent factories and mechanized agriculture that produced all of society's necessities. Many workers and peasants anticipated that they would see within their lifetimes the construction of the socialist machine age. Initially, the world war, civil war, anarchy, and plummeting industrial production frustrated these visions. The Bolsheviks would be forced to make a series of doctrinal political and economic compromises as they struggled to hold on to power and resurrect the economy. They debated how best to renovate industry, modernize agriculture, and transform the peasant into a conscious Soviet citizen, with Lenin arguing for the breathing space of the NEP, and Stalin, Trotsky, Bukharin, and others fighting after his death over how quickly to force the pace of socialist reconstruction, whether and how to encourage revolution elsewhere, or whether socialism might be built in one country as Stalin ultimately insisted. In these crucial debates that generated deep personal animosities and destroyed political careers and lives, the place of technology was a central concern.

From Lenin to Trotsky, from Kuibyshev and Kirov to Stalin, they all agreed on the importance of mastering modern technology. They were not deeply philosophical about technology's place in the modern world, but to one degree or another they recognized its transformative power and sought large-scale, society-wide diffusion of modern machinery and equipment. They remained inconsistent, however, about whether technology was apolitical, serving the profit motive of the industrialist and landowner under capitalism, but benefiting all humanity under socialism. To master technology, Lenin insisted on working with the capitalist engineer and scientist for some period of time, for he doubted the receptivity of the peasant mind to adapt overnight to socialist productive relations, even if he believed in the power of the tractor someday to transform them into new Soviet men and women. Kuibyshev, Kirov, and especially Stalin worried increasingly that reliance on the capitalist world would leave the USSR always vulnerable. While they pursued the purchase of western technology and advice for Volkhovstroi, Magnitogorsk, and other hero projects of the early USSR, they intended to rely on it only until Soviet industry could fulfill its innumerable chores of rapid modernization. While entirely fabricated, the show trials of engineers indicated the determination of the Bolsheviks to create indig-

enous technological systems—and an autarkic engineering community. Stalin would have insisted on the creation of a Bluetooth, a heavier, bulkier Soviet model, occasionally made of lacquered wood to hide its rudimentary functions or prefabricated concrete to keep its cost down. Only Trotsky seems to have been convinced that the USSR must unabashedly acquire the highest form of culture—modern technology—as rapidly as possible and apply it to the Soviet system without delay, no matter its origin.

Despite calling Trotsky a sober critic of utopianism, Fulop-Miller noted that Trotsky fell under the spell of the machine. Trotsky saw in all modern devices and techniques the key to achieving socialism in short order. The railroad, the telegraph, the road, and the tractor were all far more than symbols of socialist modernity. They were the very tools of the transformation of outmoded capitalist institutions into socialist ones. He believed that "the socialist man will rule all nature by the machine." He would drive "the dark forces of nature out of industry and ideology, and replac[e] barbaric routine with technical science and religion by the theory of knowledge." Trotsky claimed, "The Machine is not in opposition to the earth; it is a tool in the hands of the man of today in all spheres of life." Man will make "the movement of his limbs more precise, more purposeful, more economical and thus more beautiful."[114] Precisely in this utopian fascination, Trotsky embraced the view that technologies were value-neutral. They could be abused by capitalists—used to exploit the worker with the result that the worker was alienated from his labor—or used to build socialist productive relations. Trotsky used his special locomotive to put out fires of counterrevolution during the civil war. He used the radio and printing press to proselytize the glories of communism. Trotsky wore the equivalent of a Bluetooth device to assist him in bridging space and time; in bringing up-to-date information, science, and technology to the masses; and in creating *smychka* between the city and the village, between the center and the periphery, and between the arctic and the industrial heartlands. It would not matter that the Bluetooth served the capitalist in making transactions, buying commodity futures, and exploiting the worker.

Ultimately, like other convinced Russian Marxists—and capitalist entrepreneurs, businessmen, East European socialists, and engineers from the Democratic People's Republic of Korea—Trotsky saw in the most advanced technologies opportunities to overcome those problems of geography, climate, illiteracy, and backwardness that had plagued Russia. Technologies of communication—roads and railroads, telegraph, telephone, and the press—were the most important. They would unite the countryside and the cities, close the distance from Europe to the Pacific Ocean, and serve as the foundation of communism. For a variety of reasons, as the next chapters explore, most socialist leaders enunciated similar views, yet they used technology precisely for political ends, to control the masses, to make them conform to ideological precepts of good and evil, and to build industry rapidly, but at the expense of good, accessible, and inexpensive housing and health care, and accompanied by great environmental degradation. Stalinist technologies in East Central Europe represent one of the greatest betrayals of socialist rhetoric in the history of the experiment that resulted in a gray if not colorless life.

Notes

INTRODUCTION: Tractors, Steel Mills, Concrete, and Other Joys of Socialism

1. Among the many fine studies of technology under socialism, see Raymond Stokes, *Constructing Socialism: Technology and Change in East Germany, 1945–1990* (Baltimore: Johns Hopkins University Press, 2000); Pal Germuska, *Indusztria buvoleteben: Fejlesztespolitika es a szocialista varosok* (Budapest: 1956-OS Intezet, 2004); Susan E. Reid and David Crowley, eds., *Style and Socialism: Modernity and Material Culture in Post-War Eastern Europe* (Oxford: Berg, 2000); Dagmara Jajesniak-Quast, "In the Shadow of the Factory: Steel Towns in Postwar Eastern Europe," in Mikael Hård and Thomas Misa, eds., *Urban Machinery: Inside Modern European Cities* (Cambridge: MIT Press, 2008), pp. 326–56; and "Entwicklung sozialistischer Planstädte: Eisenhüttenstadt, Nowa Huta und Ostrava Kunèice im Vergleich," in Thomas Bohn, ed., *Von der "sozialistischen Stadt" zur "europäischen Stadt" und zurück? Urbane Transformationen im östlichen Europa des 20. Jahrhunderts* (München: Veröffentlichungen des Collegium Carolinum, 2008).

2. Among the important scholarship on military technology, engineering and socialism, nuclear issues, and missiles, see Ronald Amann and Julian Cooper, eds., *Industrial Innovation in the Soviet Union* (New Haven: Yale University Press, 1982); Timothy Colton and Thane Gustafson, *Soldiers and the Soviet State: Civil-Military Relations from Brezhnev to Gorbachev* (Princeton: Princeton University Press, 1990); Julian Cooper, "Western Technology and the Soviet Defense Industry," in Bruce Parrott, ed., *Trade, Technology, and Soviet-American Relations* (Bloomington: Indiana University Press, 1985), pp. 169–202; Matthew Evangelista, *Innovation and the Arms Race: How the United States and the Soviet Union Develop New Military Technologies* (Ithaca: Cornell University Press, 1988); David Holloway, *The Soviet Union and the Arms Race* (New Haven: Yale University Press, 1985), and *Stalin and the Bomb: The Soviet Union and Atomic Energy, 1939–1956* (New Haven: Yale University Press, 1994); Paul Josephson, *Red Atom* (Pittsburgh: University of Pittsburgh Press, 2005); and Asif Saddiqi, *Challenge to Apollo: The Soviet Union and the Space Race, 1945–1974* (NASA, 2000).

3. Paul Josephson, *Industrialized Nature* (Washington, D.C.: Island Press, 2002).

4. For discussions of the place of technology in the Soviet Union, see Rene Fulop-Miller, *The Mind and Face of Bolshevism*, trans. F. S. Flint and D. F. Tait (London: G. P. Putnam's Sons, Ltd, 1927); Richard Stites, *Revolutionary Dreams* (New York: Oxford University Press, 1989); Loren Graham, *The Ghost of the Executed Engineer* (Cambridge: Harvard University Press, 1993); and several other important studies cited in the notes to other chapters.

5. G. A. Cohen, *Marx's Theory of History: A Defence* (Oxford: Clarendon Press, 1978).

6. Donald MacKenzie, "Marx and the Machine," *Technology and Culture*, vol. 25, no. 3 (July 1984): 473–502.

7. Herbert Marcuse, *One-Dimensional Man* (Boston: Beacon Press, 1964). On the apolitical nature of technology, see Jacques Ellul, *The Technological Society*, trans. J. Wilkinson (New York: Vintage, 1964).

8. Kendall E. Bailes, "The Politics of Technology: Stalin and Technocratic Thinking among Soviet Engineers," *The American Historical Review*, vol. 79, no. 2 (April 1974): 445–69.

9. Amann and Cooper, *Industrial Innovation in the Soviet Union*. As Bruce Parrott points out, Soviet leaders vacillated in their gaze to the West for technology, or even the inspiration for Soviet designs, moving between periods of stronger "Amerikanizm" and hostility toward the United States. See Bruce Parrott, *Politics and Technology in the Soviet Union* (Cambridge: MIT Press, 1983).

10. Paul Josephson, "Maxim Gorky, Science, and the Russian Revolution," *Soviet and Post-Soviet Review*, vol. 22, no. 1 (1995): 15–39.

CHAPTER ONE: Would Trotsky Wear a Bluetooth?

1. David Lilienthal, *TVA: Democracy on the March* (New York: Harper and Brothers, 1944).

2. See www.marxists.org/archive/bogdanov/1923/proletarian-poetry.htm#n1#n1.

3. Rene Fulop-Miller, *The Mind and Face of Bolshevism*, trans. F. S. Flint and D. F. Tait (London and New York: G. P. Putnam's Sons, Ltd, 1927), pp. 21–22; Kendall E. Bailes, "Alexei Gastev and the Soviet Controversy over Taylorism, 1918–1924," *Soviet Studies*, vol. 29, no. 3 (July 1977): 373–94; and Zenovia A. Sochor, "Soviet Taylorism Revisited," *Soviet Studies*, vol. 33, no. 2 (April 1981): 246–64.

4. Thomas Hughes, *American Genesis* (New York: Viking, 1989).

5. Richard Stites, *Revolutionary Dreams* (New York: Oxford University Press, 1989), p. 148.

6. On the controversies between workers and managers over the introduction of Taylorism, see Hugh Aitken, *Taylorism at Watertown Arsenal: Scientific Management in Action, 1908–1915* (Cambridge: Harvard University Press, 1960).

7. Leon Trotsky, *Sochineniia*, vol. 21 (Moscow-Leningrad: Gosizdat, 1927), p. 202.

8. Trotsky, *Sochineniia*, vol. 21, p. 383.

9. Fulop-Miller, *The Mind and Face of Bolshevism*, pp. 21–22.

10. Fulop-Miller, *The Mind and Face of Bolshevism*, pp. 23–24.

11. Maurice Hindus, *Humanity Uprooted* (New York: Jonathan Cape and Harrison Smith, 1929), pp. 355–57. On the American Relief Administration, see Bertrand M. Patenaude, *The Big Show in Bololand* (Stanford: Stanford University Press, 2002).

12. On Witte and the Trans-Siberian railroad, see Steven Marks, *Road to Power* (Ithaca: Cornell University Press, 1991).

13. Hans Rogger, "*Amerikanizm* and the Economic Development of Russia," *Comparative Studies in Society and History*, vol. 23, no. 3 (July 1981): 382–420; and Kendall Bailes, "The American Connection: Ideology and the Transfer of American Technology to the Soviet Union, 1917–1941," *Comparative Studies in Society and History*, vol. 23, no. 3 (July 1981): 421–48. See also Thomas Hughes, *American Genesis*.

14. Bailes, "The American Connection." On the role of Cooper at DneproGES, see Sergei Budantsev, "Dneprovskoe stroitel'stvo," *Novyi Mir*, no. 7 (1928): 222–23. See also "American Methods Win Fight to Control Dnieper River," *Engineering News* (23 June 1932): 877; Hugh L. Cooper, "Address before the Society of American Military Engineers at the Engineers' Club, Philadelphia, February 25, 1931," *Engineers and Engineering*, vol. 48, no. 4 (April 1931); and Cooper, "Observations of Present Day Russia," *The Annals of the American Academy of Political and Social Science*, vol. 138.1 (July 1928): 117–19. See also V. I. Kazarinova and V. I. Pavlichenkov, *Magnitogorsk* (Moscow: Gosizdat po Stroitel'stvu, Arkhitekhture i stroitel'nym materialam, 1961), pp. 10–11. My thanks to Daniel C. Melega, who, as a Colby College senior, wrote a term paper entitled "The Dneprostroi Hydroelectric Dam: American Perception and Assistance towards the Building of the First of the Soviet Union's Great Hero Projects," for sharing the paper and its rich English-language sources with me.

15. Ilya Ilf and Evgenii Petrov, *Odnoetazhnaia Amerika* (Moscow: Khudozhestvennaia literature, 1937), pp. 97–99, 135–36. See https://lw.lsa.umich.edu/slavic/ilf petrov/exhibition.html, as accessed April 26, 2009, for an exhibition based on photographs and text from Ilf and Petrov's tour of America.

16. Dana G. Dalrymple, "American Technology and Soviet Agricultural Development, 1924–1933," *Agricultural History*, vol. 40, no. 3 (July 1966): 187–206.

17. Dalrymple, "American Technology."

18. Dalrymple, "American Technology."

19. Dalrymple, "The American Tractor Comes to Soviet Agriculture: The Transfer of a Technology," *Technology and Culture*, vol. 5, no. 2 (spring 1964): 191–214.

20. Dalrymple, "The American Tractor."

21. Dalrymple, "The American Tractor"; and Maurice Hindus, *Red Bread* (New York: J. Cape & H. Smith, 1931), pp. 357–58.

22. V. I. Lenin, *Sochinenie*, vol. 24 (Moscow: PartizdatTsKVKP(b), 1935), p. 170.

23. See V. B. Zagorskii, *Katalog Pochtovykh Marok. 1857–1991. Rossiia. RSFSR. SSSR*, 2nd ed. (St. Petersburg: Standart-Kollektsiia, 2007).

24. See http://ww2.lafayette.edu/~noblea/russian.htm. See also Charles A. Moser, "Mayakovsky and America," *Russian Review*, vol. 25, no. 3 (July 1966): 242–56. See also the forthcoming work of Julia Vaingurt on technology and the arts in the 1920s in the USSR, including discussion of Mayakovsky.

25. Roger Pethyridge, *The Spread of the Russian Revolution* (London: MacMillan, 1972), pp. 1–56. See also forthcoming work of Professor Tracy Nichols Busch on Russian Roads, including her "Connecting an Empire: Eighteenth-century Russian Roads, from Peter to Catherine," *Journal of Transport History*, vol. 29, no. 2 (September 2008): 240–58.

26. Pethyridge, *The Spread of the Russian Revolution*, pp. 57–74.

27. For the final program of GOELRO written "at the request of Lenin" and adopted in December 1920, see G. M. Krzhizhanovskii, "Plan elektrifikatsii RSFSR," *Izbrannoe* (Moscow: Gosizdatpolit, 1957), pp. 65–189. For more details, see Jonathan Coopersmith, *The Electrification of Russia* (Ithaca: Cornell University Press, 1992).

28. Krzhizhanovskii, *Izbrannoe*, pp. 5–6.

29. See www.marxists.org/archive/trotsky/1930/mylife/ch22.htm.

30. Trotsky, *Sochineniia*, vol. 15, p. 61.

31. Trotsky, *Sochineniia*, vol. 15, pp. 236–37.

32. Peter Kenez, *The Birth of the Propaganda State: Soviet Methods of Mass Mobilization,*

1917–1929 (Cambridge: Cambridge University Press, 1985). For articles from *Novaia Zhizn'* in translation, see Maxim Gorky, *Untimely Thoughts*, intro. Mark Steinberg, trans. Herman Ermolaev (New Haven: Yale University Press, 1995).

33. Kendall E. Bailes, "Alexei Gastev and the Soviet Controversy over Taylorism, 1918–1924," *Soviet Studies*, vol. 29, no. 3 (July 1977): 373–94; and Zenovia A. Sochor, "Soviet Taylorism Revisited," *Soviet Studies*, vol. 33, no. 2 (April 1981): 246–64.

34. Most of the articles published in the *Herald* were directed toward supporting the spread of the Marxist social sciences. The section for Taylorism offered primarily translations of recent western (German, but also American) literature on the subject of Taylorism, but it ceased in 1923, reflecting Gastev's loss of influence, and the Communist Academy itself was folded into the USSR Academy of Sciences in 1931.

35. Trotsky, *Sochineniia*, vol. 15, p. 85.

36. Trotsky, *Sochineniia*, vol. 15, pp. 92–93.

37. Trotsky, *Sochineniia*, vol. 15, p. 108.

38. Trotsky, *Sochineniia*, vol. 15, pp. 34–35.

39. Trotsky, *Sochineniia*, vol. 21, p. 261.

40. Trotsky, *Sochineniia*, vol. 21, p. 262.

41. Trotsky, *Sochineniia*, vol. 21, p. 263.

42. Trotsky, "Dialectical Materialism and Science" (1925), published in *New International*, vol. 6, no. 1 (February 1940): 24–31, as accessed at www.marxists.org/archive/trotsky/1925/09/science.htm.

43. Trotsky, *Sochineniia*, vol. 15, pp. 7, 10, 13.

44. Trotsky, *Sochineniia*, vol. 15, p. 35.

45. Neil Heyman, "Leon Trotsky's Military Education: From the Russo-Japanese War to 1917," *Journal of Modern History*, vol. 48, no. 2 (On Demand Supplement, June 1976): 71–98.

46. Trotsky, *Sochineniia*, vol. 9, p. 188.

47. Trotsky, *Sochineniia*, vol. 9, p. 187.

48. Heyman, "Leon Trotsky's Military Education."

49. Trotsky, *Sochineniia*, vol. 15, p. 51.

50. Trotsky, "Radio, Science, Technique and Society" (1926), available at www.marxists.org/archive/trotsky/1926/03/science.htm.

51. Trotsky, *Sochineniia*, vol. 21, p. 417.

52. Trotsky, "Radio, Science, Technique and Society."

53. Lenin, *Collected Works*, vol. 34, p. 247.

54. Steven Solnick, "Revolution, Reform and the Soviet Telephone System, 1917–1927," *Soviet Studies*, vol. 43, no. 1 (1991): 157–76.

55. Gosudarstvennyi Arkhiv Arkhangelskoi Oblasti, Otdel DSPI, F. 290, op. 2, d. 319, l. 15.

56. J. Patrick Lewis, "Communications Output in the USSR," *Soviet Studies*, vol. 28, no. 3 (July 1976): 406–17.

57. For discussion of the growing awareness among the intelligentsia of the many obstacles to lifting the peasantry into the nineteenth century after the 1861 emancipation, see Cathy Frierson, *Peasant Icons* (New York: Oxford University Press, 1993).

58. James Scott discusses the various efforts to achieve this goal of production of aggregated knowledge of the world by political actors in *Seeing Like a State* (New Haven: Yale University Press, 1998).

59. Trotsky, *Sochineniia*, vol. 21, pp. 359–60.

60. Trotsky, *Sochineniia*, vol. 21, pp. 377, 380.

61. Trotsky, "Kultura i sotsializm," *Novyi Mir*, no. 1 (1927): 176.

62. In the open-field system each peasant family might farm several narrow, noncontiguous strips of land in a field at some distance from home.

63. Trotsky, *Sochineniia*, vol. 21, p. 380.

64. Trotsky, *Sochineniia*, vol. 21, p. 379.

65. Trotsky, "Radio, Science, Technique and Society."

66. Trotsky, *Sochineniia*, vol. 21, p. 366.

67. Trotsky, *Sochineniia*, vol. 21, pp. 410–11.

68. Matthew Payne, *Stalin's Railroad: Turksib and the Building of Socialism* (Pittsburgh: University of Pittsburgh Press, 2001).

69. Trotsky, "Kultura i Sotsializm," pp. 177–78.

70. Trotsky, "Kultura i Sotsializm," p. 178.

71. Leon Trotsky, *Whither Russia?* (New York: International Publishers, 1926), p. 57.

72. Trotsky, *Whither Russia?* pp. 106–9.

73. Douglas Weiner, *Models of Nature* (Bloomington: Indiana University Press, 1988).

74. Trotsky, *Literature and Revolution*, trans. Rose Strunsky (New York: International Publishers, 1925), p. 251.

75. On large-scale, government-sponsored nature transformation projects in the American West, see Mark Reisner, *Cadillac Desert* (New York: Viking, 1986). On the economic and technological roots of the Dust Bowl in the 1930s, see Donald Worster, *Dust Bowl* (New York: Oxford, 1979).

76. Trotsky, *Sochineniia*, vol. 21, pp. 382–83.

77. Trotsky, *Sochineniia*, vol. 21, pp. 417–18.

78. Trotsky, *Sochineniia*, vol. 21, pp. 418–20.

79. For the classic discussion of the attitudes of Stalin and other leaders and their relationship with specialists, see Kendall Bailes, *Technology and Society under Lenin and Stalin* (Princeton: Princeton University Press, 1978).

80. Stalin, *Politicheskii Otchet Tsentral'nogo Komiteta XIV S"ezdu Rossiiskoi Kommunisticheskoi partii (Bolshevikov)* (Moscow-Leningrad: Gosizdat, 1926), pp. 26–28.

81. Stalin, *Politicheskii otchet XIV S"ezdu*, pp. 39–40.

82. Vladimir Ipatieff, *The Life of a Chemist* (Stanford: Stanford University Press, 1946).

83. Loren R. Graham, "Bukharin and the Planning of Science," *Russian Review*, vol. 23, no. 2 (April 1964): 135–48.

84. For discussion of the unfolding industrialization debates, the relative weight of investment in industry or the countryside, the resulting policies toward the peasantry, and the positions of such figures as Trotsky, Nikolai Bukharin, Evgenii Preobrazhensky, Stalin and his followers, and others, see Alexander Ehrlich, *The Soviet Industrialization Debate, 1924–1928* (Cambridge: Harvard University Press, 1960).

85. V. V. Kuibyshev, *Izbrannye Proizvedeniia* (Moscow: Gosizdatpolit, 1958), p. 102.

86. Kuibyshev, *Izbrannye Proizvedeniia*, pp. 104–5.

87. Kuibyshev, *Izbrannye Proizvedeniia*, pp. 117–18.

88. Kuibyshev, *Izbrannye Proizvedeniia*, pp. 252–53.

89. G. A. Beresnev and Iu. Gromov, *Ogni Sedogo Volkhova* (Leningrad: Lenizdat, 1967), pp. 12–13, 22.

90. Beresnev and Gromov, *Ogni Sedogo Volkhova*, pp. 70, 157, and www.nohab-gm.hu/en/eno5_5.html.

91. D. Saslavsky, *Dnieprostroi: The Biggest Dam in the World* (Moscow: Cooperative Publishing Society of Foreign Workers in the USSR, 1932), pp. 3–4, 8–10.

92. Beresnev and Gromov, *Ogni Sedogo Volkhova*, p. 139.

93. "K novym sversheniiam," *Elektrosila*, vol. 32 (M-L: Gosenergoizdat, 1979), pp. 3–4. For popular discussions of the glory of the Volkhovsk hydroelectric power station, see A. V. Blokhnin, *Maiak Sovetskoi Vlasti* (Moscow: Gospolitizdat, 1961); and Boris Galin, *V Grozu i Buriu: Kratkaia Istoriia Volkhovstroia* (Moscow: Sovetskaia Rossiia, 1967).

94. Beresnev and Gromov, *Ogni Sedogo Volkhova*, pp. 94–97, 139.

95. S. M. Kirov, *Izbrannye Stat'i i Rechi, 1912–1934* (Leningrad: OGIZ RSFSR, 1939), pp. 238–39.

96. Kirov, *Izbrannye*, pp. 405–7.

97. Kirov, *Izbrannye*, pp. 469, 632–33.

98. Bailes, *Technology and Society under Lenin and Stalin.*

99. Stalin, *Political Report to the Sixteenth Party Congress of the Russian Communist Party* (New York: Workers' Library Publishers, 1930), pp. 34–55.

100. D. Saslavsky, *Dnieprostroi: The Biggest Dam in the World*, pp. 18–19.

101. V. I. Kazarinova and V. I. Pavlichenkov, *Magnitogorsk* (Moscow: Gosizdat po Stroitel'stvu, Arkhitekhture i stroitel'nym materialam, 1961), p. 15; and John Scott, *Behind the Urals* (Boston: Houghton Mifflin, 1942).

102. Feshbach and Friendly, *Ecocide*, pp. 92–93. On Magnitogorsk, see Stephen Kotkin, *Steeltown USSR* (Berkeley: University of California Press, 1991).

103. On the role of the Weimar government in trying to free the German defendants and protect German economic interests, see Kurt Rosenbaum, "The German Involvement in the Shakhty Trial," *Russian Review*, vol. 21, no. 3 (July 1962): 238–60.

104. N. V. Krylenko, *A Blow at Intervention. Final Indictment in the Case of the Counter-revolutionary Organisation of the Union of Engineers' Organisations (the Industrial Party)* (Moscow: State Publishers, 1931).

105. Arthur Feiler, *The Experiment of Bolshevism*, trans. H. J. Stenning (London: George Allen and Unwin, 1930), p. 100.

106. Nikolai Pogodin, *Sobranie Sochinenii* (Moscow: Iskusstvo, 1972), p. 113.

107. Pogodin, *Sobranie*, p. 63. Pogodin also gave us *Aristocrats*, a play that takes place at the Belomor Prison Camp where tens of thousands of prisoners died, and the roster of roles includes a full quotient of Chekists, specialists, bandits, criminals, kulaks, and others. See ibid., pp. 347–412.

108. On this debate, see Paul Josephson, "Science and Ideology in the Soviet Union: The Transformation of Science into a Direct Productive Force," *Soviet Union*, vol. 8, pt. 2 (1981): 159–85.

109. Stalin, *The Tasks of the Working Class in Mastering the Technique of Production* (New York: Workers' Library Publishers, 1931), p. 8.

110. Stalin, *Sochineniia*, vol. 13 (Moscow: OGIZ, 1946–47), pp. 37–38.

111. Stalin, *Sochineniia*, vol. 13, p. 41.

112. Stalin and St. Kosior, *Otchet Tsentral'nogo Komiteta XV S"ezda VKP (b)* (M-L: Gosizdat, 1928).

113. Stalin, *Itogi Pervoi Piatiletki* (M: Partizdat, 1933).

114. Fulop-Miller, *The Mind and Face of Bolshevism*, p. 214.

CHAPTER TWO: Proletarian Aesthetics

Epigraph: Ivan Martinov and Nikolai Zidarov, eds., *Dimitrovgrad. Stixhove i Ochertsi* (Sofia: Bulgarski Pisatel, 1951), pp. 132–34.

1. James Aulich and Marta Sylvestrova, *Political Posters of Central and Eastern Europe, 1945–95* (Manchester: Manchester University Press, 1999), p. 140.

2. In *Constructing Socialism: Technology and Change in East Germany, 1945–1990* (Baltimore: Johns Hopkins University Press, 2000), Raymond Stokes evaluates the state of East German industry after the war and the challenges to indigenous innovation under socialism, including divorce from western specialists and the enforced role of East German technology and specialists in the USSR.

3. For evidence of this, see various chapters in Gordon Smith, Peter Maggs, and George Ginsburgs, eds., *Soviet and East European Law and the Scientific Technical Revolution* (New York: Pergamon, 1981).

4. See, for example, Leon Trotsky, "Kultura i Sotsializm," *Novyi Mir*, no. 1 (1927): 175–78.

5. Leszek Zachuta, *Historia Przemystu Cementowego w Polsce, 1987–2000* (Krakow: Polski Cement, 2004).

6. Gy. Varga, "The Long-run Development of Hungarian Industry," *Acta Oeconomica*, vol. 32, nos. 1–2 (1984): 91–112. In Hungary, for example, of 702 state enterprises, only 36 had a workforce of 50 or less, while in 39 enterprises the workforce exceeded 5,000.

7. See Geoffrey Swain's "Deciding to Collectivise Latvian Agriculture," *Europe-Asia Studies*, vol. 55, no. 1 (2003): 39–58.

8. Deborah Fitzgerald, *Every Farm a Factory* (New Haven: Yale University Press, 2003).

9. A variation on Stalin's hypocritical observation in 1930 that signaled only a short break in the siege on the Soviet countryside, "Life is becoming gayer, Comrades!"

10. As cited in Martin Horak, "Environmental Policy Reform in the Post-communist Czech Republic: The Case of Air Pollution," *Europe-Asia Studies*, vol. 53, no. 2 (2001): 13.

11. For crucial contributions to discussion of hero cities, see Dagmara Jajesniak-Quast, "In the Shadow of the Factory: Steel Towns in Postwar Eastern Europe," in Mikael Hård and Thomas Misa, eds., *Urban Machinery: Inside Modern European Cities* (Cambridge: MIT Press, 2008), pp. 326–56; and "Entwicklung sozialistischer Planstädte: Eisenhüttenstadt, Nowa Huta und Ostrava Kunèice im Vergleich," in Thomas Bohn, ed., *Von der "sozialistischen Stadt" zur "europäischen Stadt" und zurück? Urbane Transformationen im östlichen Europa des 20. Jahrhunderts* (München: Veröffentlichungen des Collegium Carolinum, 2008).

12. Hungary Five Year Plan, *The First Five-Year Plan Act of the Hungarian People's Republic*, n.c., n.p., 1950.

13. Hungary Five Year Plan, *The First Five-Year Plan Act of the Hungarian People's Republic*, n.c., n.p., 1950.