Chapter 13

Faster, Faster

WRITING in the year 1904, Henry Adams—"an elderly and timid single gentleman in Paris," as he described himself—recorded his astonishment at the year-by-year expansion of steam power and electric power, and at the discovery of radioactivity; and he propounded a "law of acceleration." The amount of force at the disposal of mankind was increasing faster and faster, he noted. "The coal output of the world, speaking roughly, doubled every ten years between 1840 and 1900, in the form of utilized power, for the ton of coal yielded three or four times as much power in 1900 as in 1840." And he looked forward to a fantastic future, in which the forces available to man would multiply until "the new American—the child of incalculable coal power, chemical power, electric power, and radiating energy, as well as of new forces yet undetermined—must be a sort of God compared with any former creature of nature."

At the rate of progress since 1800, continued Adams, "every American who lived into the year 2000 would know how to control unlimited power. He would think in complexities unimaginable to an earlier mind. He would deal with problems altogether beyond the range of earlier society. To him the nineteenth century would stand on the same plane with the fourth—equally childlike—and he would only wonder how both of them, knowing so little, and so weak in force, should have done so much."

At the mid-century a thoughtful observer of the startling progress of American technology is likely to feel a bewilderment akin to that which Adams felt in 1904. For the application of power to the circumstances of American life has not only increased at a dizzy pace since Adams's time, but has seemed to be accelerating sharply, with the promise of further leaps ahead. In the latter nineteen-thirties many economists had come to the conclusion that the United States had arrived at a "mature economy"; instead, we have been witnessing a technological revolution comparable to that which followed the introduction of steam, and far more rapid. During the fifteen years from 1935 to 1950 American technology took a stride forward at least as impressive as that which Henry Ford's assembly line dramatized in earlier years; and from all appearances this was not the culmination, but merely a preliminary phase, of a process of change which in time would profoundly alter the working and living conditions of the people.

We have already noted, in Chapter 11, how the coming of World War II unlocked the productive powers of American industry; how the manufacturers, when asked to go ahead and produce with little regard for cost or for anything else except quantity and speed, went into a burst of activity which astonished the world. But we have given only passing mention to the way in which the war stimulated invention and technological change. What the government, through its Office of Scientific Research and Development and other agencies, was constantly saying during the war was, in effect: "Is this discovery or that one of any possible war value? If so, then develop it and put it to use, and damn the expense!" The result has been likened to a team of experts combing through a deskful of scientific papers, pulling out those which gave promise of usefulness, and then commandeering all the talent and appropriating all the money that might be needed to translate formulae into goods of military value.

The classic example, of course, is the way in which, following the splitting of the atom in 1939 and the confirmation of this event by American experiments in 1940, the government presently launched the Manhattan Project, at a cost of billions, and compressed into less than five years of research and engineering and manufacturing experiment and development what might otherwise have taken a generation to accomplish. But there were other examples innumerable. For instance, it was in 1929 that Alexander Fleming first described penicillin. Long years went by before the possibilities of what he had discovered were realized. Not until the war came was penicillin adapted for medicinal use. But then the work was pushed with such speed that before the end of the war the drug was being supplied in vast amounts. Still another example was the pioneer work done by Robert Watson-Watt and other British investigators in the development of radar, under the awful necessity of protecting England from German bombs; the utilization of their findings in the American manufacture of radar equipment on the grand scale; and the resulting education of thousands of young Americans in the principles and possibilities of electronics.

Each of these developments which I have cited was based, in large part, upon scientific discoveries made abroad. We should remember that the metaphorical deskful of papers of which I have spoken was international; much if not most of the fundamental work out of which grew the new wartime products and devices was European. What the United States contributed most effectively was a capacity for the organization of research, especially in applied science; the ability to set up brisk production lines; and a zest for doing big things at top speed.

The war crisis brought together as never before the pure scientist, the applied scientist, the manufacturing executive, the military officer, and the government administrator, and put them into a partnership which mightily affected their future understanding of one another. The physicist or chemist who had been cloistered in a university laboratory, and had taken a special pride in paying no heed to the possible practical application of his findings, was thrust into emergency work of the most lethally practical sort, and hauled off to Washington to consult with generals and admirals and bureaucrats and engineers and manufacturers; and these others acquired a new respect for his scholarly ardor, now suddenly so vital to them. The question has been raised whether the quality of disinterested academic investigation was not somehow tarnished in the process, and especially whether the continuing diversion of much scientific talent into specific projects for the government even after 1945 may not have slowed our advance in pure science. But certainly there took place during the war a cross-fertilization of thinking which was stimulating to all concerned. Many a professor was enlivened by his new contacts, and many an industrial executive went home from Washington with a new insight into the future potential of scientific research.

All in all, during the war American technology underwent a hothouse growth.

II

Meanwhile the war-induced prosperity was speeding technological change on a quite different level. The jingle of cash in the pocket was preparing innumerable ordinary Americans to buy and use more machines just as soon as these became available. And after V-J Day the rush was on.

Everybody, to begin with, seemed to want new automobiles, which had been unavailable for purchase during the war. There was hot competition for the joy of getting a new car fresh from the assembly line; people talked about the number of months or years that they had "had their name in" with dealers; there was a lively racket in ostensibly used cars; and it was years before the automobile manufacturers could catch up with the demand. After they had done so, in the single year 1950 they sold more than eight million vehicles —which was more cars than had existed in the entire United States at the end of World War I.

But that wasn't the half of it. During these postwar years the farmer bought a new tractor, a corn picker, an electric milking machine; in fact he and his neighbors, between them, assembled a formidable array of farm machinery for their joint use. The farmer's wife got the shining white electric refrigerator she had always longed for and never during the Great Depression had been able to afford, and an up-to-date washing machine, and a deep-freeze unit. The suburban family installed a dishwashing machine and invested in a power lawnmower. The city family became customers of a laundromat and acquired a television set for the living room. The husband's office was air-conditioned. And so on endlessly.

Few of these machines for working and living were new in principle. Many had been on the market and in use for a long time. Essentially it was prosperity which put these and other machines into widespread use—prosperity plus a variety of sometimes mutually antagonistic forces, such as, for example, the electric-utility industry, enemy-to-the-death of the New Deal, and the Rural Electrification Administration, offspring of the New Deal, which between them were at least partly responsible for the remarkable progress in the electrification of American farms. In 1935 only about 10 per cent of American farms were electrified; by 1950, more than 85 per cent were.

A one-time resident of Arkansas, returning to Fayetteville at the mid-century after a prolonged absence, remarked that the most eye-opening thing about the farms he saw in the neighborhood was that almost all were electrified; in his boyhood an electric-lighted farm had been a rarity. At about the same time the editors of a popular magazine planned to publish a picture story on the daily routine of a farmer's wife; they abandoned the project because the farmers' wives that their correspondents and photographers had encountered had so much mechanical kitchen equipment that they could hardly be distinguished photographically from other housewives. In 1950 a British "productivity team" visited America to study the agricultural methods in use, and visited a large number of farms from New Jersey to Nebraska, with their interest focused, not on the spectacularly large farm with its intensive mechanization, but on the family-size farm run by the farmer and his family with the aid, perhaps, of one hired hand. They noted not only the widespread and increasing use of such things as tractor plows, disk harrows, corn planters, corn pickers, combine harvesters, milking machines, self-unloading trailers, and so on, but also the fact that on farm after farm the work was being reorganized to take advantage of machinery. The farmer no longer thought of a machine simply as an efficient and untiring substitute for a horse, or for human effort, but as a device which would enable him to go about his business in a new way—using a hay dryer to preserve the vitamins in his cattle feed, for instance, or substituting for the electrical milking of cows in a traditional stanchion barn the building of a "milking parlor" adjacent to an open cattleshed or "loafing barn."

During the nineteen-forties the number of farm workers shrank from 9½ millions to only a little over 8 millions. Nevertheless farm production increased by 25 per cent. This was partly, of course, because prosperity at home and food shortages abroad had broadened the market; but partly it was because farmers, like other Americans, were using more and more machines, old and new, in their daily life.

III

Simultaneously the rising wage rates in American factories were prompting a restless search for labor-saving methods of production. These took innumerable forms, some of them based upon sheer elementary common sense—"Can't we dream up a machine to do the work that those unskilled workers are sweating over?" or "Why not redesign this floor of the factory so that the work won't have to be lifted by hand from this point to that, but will move smoothly from job to job by conveyor belt?"—while others involved scientific formulae and mechanical assemblies of the utmost complexity.

The common-sense labor-saving devices would make a long list—overhead cranes, conveyors of all sorts (gravity rollers, skate rollers, belt conveyors), power grabs for picking up unit loads, power-driven hand tools, the use of compressed air for cleaning, and so forth. Typical, perhaps, in its simplicity and its significance is the use of the fork truck and pallet: the fork truck being a sturdy little truck equipped with a fork—or pair of metal fingers—with which it can pick up goods, lift them high, and carry them from point to point; and the pallet being simply a double-bottomed tray on which cartons or bundles of goods can be piled for such transportation. The fork truck can insert its metal fingers between the two layers of a loaded pallet on a freight car, lift it, carry it to its appointed place in the factory, put it carefully in place, and then withdraw the metal fingers and return for another load. All very simple; nothing abstruse about it. But anybody who has watched the laborious unloading of trucks across a city sidewalk—one man lifting cartons out of the truck, another man toting them indoors, to be taken by a third man to their proper place in the building—can realize the amount of human heaving and hauling that the fork truck and pallet eliminate. For all this effort is substituted the work of one man, driving about in his fork truck and manipulating with precise skill the metal fingers of his fork. Such contraptions are symbolic of a whole class of labor-saving devices in that they regard human labor as expensive and therefore to be conserved, while the wood or plastic that goes into the making of pallets is plentiful and comparatively expendable.

Anybody can understand the basic principle of a fork truck. But the layman can only stand in awe before some of the complex electronic machines which came into use during the period between 1935 and 1950—machines for measuring materials with microscopic exactitude, or for watching the performance of a machine and automatically correcting flaws in its performance. The language used by engineers in talking about them is quite unintelligible to him, as are the processes involved. But at least he can appreciate the miraculous results they achieve. They can count and inspect the goods coming off an assembly line, passing or discarding them as faithful or unfaithful to the specifications. They can check, with incredible precision, the exact thickness of a sheet of steel, or discover the hidden flaws inside a mass of metal. They can watch the work of a machine with an eye of superhuman vision, and start, stop, regulate the machine in accordance with their observations. Here again, though the scientific principles at work are far beyond lay comprehension, the symbolic significance is clear: you can not only dispense with even a reasonably skilled workman by building into a machine all the foreseeable motions with which he might react to variations in the task before him, but you can even provide the machine with eyes much sharper and reactions much prompter than his. With such appliances coming into use, no wonder the most striking thing about many a factory floor, today, is the multiplicity of machines and the almost total absence of machine tenders.

Another innovation which came into use during this same period has a somewhat different significance. It does not eliminate the workman; instead, it makes him a less wasteful and more responsible performer. This is "quality control"—a system of taking an occasional sample of the work produced by a given machine, submitting this sample to the most minute electronic inspection, and recording on a chart just how it deviates from absolute perfection. The workman, consulting this chart, can thereupon regulate the adjustment of his machine, not by guesswork, but with exact knowledge of just how it is functioning. This device—which in many a factory has saved large amounts of money by reducing the number of defective products—has the effect of raising the status of the workman by making him in a special sense his own boss, the informed critic and judge of his performance.

What has been the cumulative effect of the introduction of such varied machine methods? First, it has reduced sharply the demand for unskilled labor. In 1900 there were some eleven million "common laborers" (including those on the farms) in the United States; by 1950 there were less than six million. At the other end of the spectrum it has increased tremendously the demand for engineers and technicians. At the beginning of the century, according to President Conant of Harvard, chemical engineering had not developed as a profession; "today [he was speaking in 1951] there is a great shortage of chemical engineers in spite of the fact that more than 15,000 have been trained in the last five years." As for engineers in general, they increased in number from about 40,000 in 1900 to about 400,000 in 1950, and still there was such a furious demand for them—intensified by the Korean war—that in 1951 the students graduating from engineering schools were being looked over by talent-scout teams from over four thousand companies, and one university placement officer declared, "Even our worst students have had at least three offers."

The economist Colin Clark has called attention to the fact that as an industrial civilization becomes more advanced, there tends to be a movement of people out of farming into industry, and then out of industry into what he calls the "services"—meaning business, trade, transportation, entertainment, the professions, etc. This movement has certainly been taking place in the United States. Since 1900 the proportion of Americans engaged in farming has taken a big drop; the proportion engaged in industry, overall, has changed very little; the proportion engaged in the "services" has jumped upward. Take this fact in conjunction with the facts about the shift within industry and we emerge with a general finding: At the mid-century there are fewer and fewer people working with their hands, more and more people working at desks; fewer workers with brawn, more workers with brain; fewer whose jobs require only a limited education, more who need an advanced education.

There are still many dark satanic mills in the United States. There are still numerous jobs of grinding effort or wearisome monotony. Even the most automatic factory has to employ maintenance men, sweepers, cleaners; these men's work has been very little mechanized, and they tend to form a sort of new proletariat of the machine age. Yet the general trend is toward an enhancement of the dignity of labor.

Ever since Henry Ford set up his assembly line we have been hearing lamentations over the tendency of the factory to turn a man into a robot, to make him a mere mechanical bolt-tightener, hour upon hour. Dreadful pictures have been drawn of the completely mechanized future day when man would be dehumanized by such labor. But what has actually been happening, increasingly, is that a machine has been put to work tightening those everlasting bolts; that the man who formerly tightened them, or his counterpart, is either managing a more intricate machine, or sitting at a desk studying engineering reports; while the man who formerly broke his back lifting bundles of goods is sitting at the controls of a conveyer. For the principle that has been at work is this: If the job is unendurably heavy or monotonous, that's a pretty good sign that you can get a machine to do it.

IV

Like scouts moving before an advancing column of troops, the investigators and engineers of pure and applied science have meanwhile been moving ahead. For well over a generation, now, the chemists and chemical engineers have been ringing the changes on an idea mentioned in an earlier chapter of this book, the idea that "synthetic" materials can do better than merely imitate nature: they can actually improve on nature. It was before World War II—on October 25, 1939, to be exact—that they produced the climactic demonstration of this idea; that was when nylon stockings first went on sale. During the nineteen-thirties and the war years, other pioneers of technology succeeded in adapting the Diesel engine—that long-neglected source of power—to widespread use on the railroads and in industry. They developed high-octane gasoline into a plentiful source of power for airplanes. They brought the production of synthetic rubber to a point where it served, not merely as a war substitute, but as a product of continuing value for a nation on wheels. They found out how to use tungsten-carbide cutting tools for immensely rapid machine-tool operations. And they made medical history by discovering the merciful possibilities of the antibiotics.

As for atomic power—their most imposing achievement—we already have been shown its deadly possibilities; what its beneficent ones may be is still uncertain, in view of the fabulous cost of producing it, but they might well, in time, make man—in Adams's words—"the child of incalculable power."

In the field of aviation the working of Adams's law of acceleration has been strikingly exemplified. In 1935 there was no transoceanic flying except on an adventurous and experimental basis; scarcely a dozen years later, the first question asked of anybody who said he was leaving for Europe was, "Are you going to fly or go by boat?" By the end of the war we saw the arrival of the jet plane; within a few years thereafter, the speed of planes was reported to have passed the supposedly impassable sonic barrier; by 1950 the exploration of the upper air had reached a point where sober men of science were talking in matter-of-fact tones about the chances for space travel.

In quite different fields one encounters startling evidence of the way in which the advance of research has been transforming American businesses—as when one hears from an official of the Corning Glass Works that more than 50 per cent of Corning sales in 1950 was in products which did not exist commercially ten years earlier.

The nineteen-forties were a heyday for the chemists and chemical engineers. The oil industry, for instance, happily discovered that, as Carroll Wilson has put it, "there were things more valuable than fuel in a barrel of crude oil," and, beginning about 1942, built a number of continuous-flow chemical plants which rivaled the wildest fantasies of an H. G. Wells. In these strange new factories with their shining fractionating towers and their latticeworks of bright-colored pipes, "the raw material, fluid or gas, flows continuously in at one end, passes through intricate processing stages, and debouches in a twenty-four-hour stream of products at the other," wrote the editors of *Fortune* in their 1951 book, *U.S.A., the Permanent Revolution.* And what a variety of products—ranging from fertilizer to detergents, from cosmetics to refrigerants, from synthetic rubber to printer's ink! Nowadays the petrochemists, sitting in their laboratories and drawing pictures of arrangements of molecules that look like diagrams of football plays, see themselves as the architects of a multifold new industrial era.

But perhaps it is not to the chemists, but to the physicists, that one should look for the most startling future discoveries; or to co-ordinated efforts by physicists, chemists, biologists, and mathematicians. In the year 1948 chemistry gave us cortisone, that minister of comfort and shaker of medical theory; in the same year physics produced the transistor, a tiny device which may well supersede the vacuum tube. The half century was hardly over before co-ordinated researches developed krilium, a soil conditioner of unguessed potentialities. And there are hardheaded men who believe that the joint efforts of physicists, chemists, and biologists may be taking us to the threshold of accomplishing the miracle of photosynthesis—of producing food from light as plants produce it.

Perhaps Henry Adams was not so far wrong with his prediction that "every American who lived into the year 2000 would know how to control unlimited power." Certainly things have been accelerating at the mid-century.