Chapter 24

PROGRESS IN SCIENCE AND TECHNOLOGY

INTRODUCTION

What signifies philosophy that does not apply to some use?

BENJAMIN FRANKLIN

The Congress shall have power . . . to promote the progress of science and useful arts by securing for limited times to authors and inventors the exclusive right to their respective writings and discoveries.

U.S. CONSTITUTION, I:8

I've been up to th' top iv th' very highest buildin' in town, Hinnissy, an' I wasn't anny nearer Hivin thin if I was in th' sthreet. Th' stars was as far away as iver. An' down beneath is a lot iv us runnin' an' lapin' an' jumpin' about. . . . Pro-gress, oho! I can see th' stars winkin' at each other an' sayin': "Ain't they funny! Don't they think they're playin' hell!"

FINLEY PETER DUNNE ("MR. DOOLEY")

PROGRESS ALWAYS MEANS improvement, or change for the better. In that formulation, "change" is just as necessary as "improvement." A nation cannot progress unless it changes, though it can change without improving.

In America, there is no question about the change. In the last 200 years, the country has undergone enormous change. At the end of the eighteenth century the United States had a population of about 5 million; it now has a population of over 200 million. That fortyfold increase is not matched by any other major nation in modern times. Similarly striking quantitative increases are manifested in the expansion of the national product and national wealth, in the growing complexity of government and social organization, in the increase of military and commercial power, and the like. Even more striking qualitative changes may be observed. From a predominantly agricultural country that exported raw materials and imported finished products and ideas, the United States has become a predominantly industrial country that exports finished products and also ideas, not only to the underdeveloped countries but even to Europe.

In fact, it is harder to think of one thing about America that has remained unchanged in two centuries than to list a hundred things that have changed in radical ways.

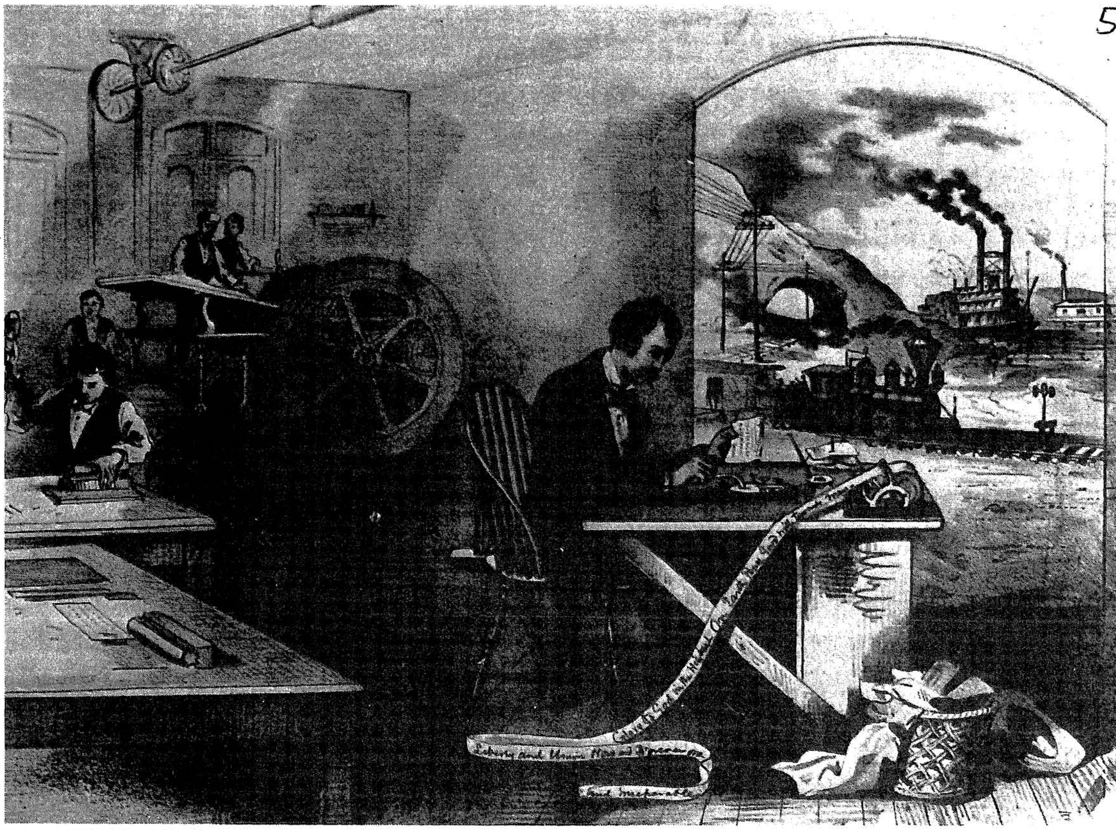
Progress, however, is not only change; it is also improvement. And while all agree that America has changed, not all feel that the change has been for the better.

In a sense, our ambivalence about progress is shared by people all over the world. Since World War I, if not before, many writers in the West have tended to view the accelerating changes of our time with a somewhat jaundiced eye. They have been especially critical of the technological advances that have given our era its special character, and they have seriously questioned whether man's increasing mastery of nature has been accompanied by, to say nothing of having resulted in, an improvement in man and in his way of life.

In another sense, doubts about progress are unique to our country. We Americans have not had to suffer most of the ills that have afflicted Europeans in this century — national poverty and want, class antagonism and conflict, invasion, conquest, and military occupation, loss of power and prestige. Our anxiety about progress, while it may be based to some extent on a fear of these eventualities, seems to have another and perhaps a more basic source. This is our paradoxical attitude toward nature. On the one hand, we, in common with most peoples of the Western world, have tried to subdue nature — and our efforts have, on the whole, been crowned with success. But, on the other hand, we have also tended to respect, almost to worship, nature. Perhaps no nation has been so wasteful of its natural resources; at the same time, however, probably no nation has conserved at least some of them so religiously. As a modern poet has said, we are like a murderer who weeps for his victim.

What is more, this ambivalence about progress, particularly about technological progress, goes back very far in our history, as it does not in the history of European nations. Support and promotion of applied science is reflected in our basic law — in the Constitution and in the great legal documents that preceded and helped form it; we have prided ourselves on our ingenuity for more than 200 years, and have tended to see it as the main source of our growth and prosperity. However, nostalgia for the primitive, the simple, the "natural" goes back almost as far in our national consciousness. And few Americans of the present day do not experience at least an occasional hankering to know what it was like to live here before science and technology changed a wild paradise into the most powerful and productive nation on earth.

This fundamental ambivalence is reflected in many of the passages cited in this chapter. However, other matters are also touched on. For a long time, Americans have had a sense — whether the feeling was really supportable is another question — of being in the forefront of progress. Our national attitudes toward, and reliance on, applied science are of particular note in this regard. One result — perhaps it is also a cause — of our respect for science has been the deep (latterly, the costly) involvement of government in scientific pursuits. Technological *changes* are a fact (as distinguished from technological progress, which is a judgment about the facts); and those changes have had marked effects, especially on agriculture and industry, that in turn have affected our style and standard of living. Finally, the changes that have occurred have produced what some contemporary writers call a "technological society" — one marked by the technical organization of modes of ordinary life. The question of whether such an organized style of life is good or bad, and the even more compelling question of whether it is likely to become largely or even wholly "technological" in the future, are subjects with which this discussion concludes.



Museum of the City of New York, Harry T. Peters Collection

"The Progress of the Century"; lithograph by Currier and Ives for the centennial celebration, 1876

1. THE AMERICAN FAITH IN PROGRESS

As EARLY AS 1780 the Englishman Thomas Pownall could point, in "A Memorial Most Humbly Addressed to the Sovereigns of Europe on the Present State of Affairs, Between the Old and New World," to an "ingenuity of mechanic handicraft" that manifested itself in most of the aspects of everyday life. America's efforts were particularly notable in agriculture and commerce; and when it came to a "comparison of the spirit of civilizing activity in the Old and in the New World," Pownall ventured to assert that "North America has advanced, and is every day advancing, to growth of state, with a steady and continually accelerating motion, of which there has never yet been any example in Europe."

Similar and no less enthusiastic encomiums may be found in all eras of our history. "Where American ingenuity has been put to trial it has never failed," Charles J. Ingersoll was so bold as to claim in 1823. "In all the useful arts," he declared, "and in the philosophy of comfort — that word which cannot be translated into any other language, and which, though of English origin, was reserved for maturity in America — we have no superiors." An editorial in the *Scientific American* in 1859 echoed Ingersoll's sentiments. Its ingenuity "is winning for America a name among the nations of the world of more value to real progress than conquest, shrines, or ancestry," it said. "Americans, by their mechanical skill, are contesting in the glorious field of the liberal arts and are gaining peaceful victories on the continent of Europe of more importance to the world than Austerlitz or Waterloo." To prove its point, the editorial cited homely examples. "Reaping machines are greater civilizers than swords and Yankee unpickable locks greater securities to property than jails or gallows."

A generation later the prevailing opinion had not altered. "The spirit of American civilization is eminently progressive," wrote Josiah Strong in 1893. "The increase of our population, the springing up of new cities and the growth of old ones, the extension of our railway and telegraph systems, the increase of our agricultural, manufacturing, and mining products, the development of our natural resources, the accumulation of our national wealth — all these are simply enormous. Such are the progress of invention and the increase of knowledge, and such is the rapidity with which important changes jostle each other, that years seem like generations."

Nor had America's conception of itself altered fifty years later. "Critics say we cannot Americanize the world — that forcing the American way down the throats of foreign peoples smacks of dictatorship and power politics," declared Frederick G. Crawford, then president of the National Association of Manufacturers, in 1943. "Let me assure you," he went on to say "— no force will be needed. Foreign industry envies us our productive capacity and skill — mimics us wherever it can. The people, whenever they've had the opportunity to know American goods, have reached eagerly for more. Denied the American standard of living at home, they have thronged to our shores by the millions."

Crawford wrote during World War II; it was his intent to convince manufacturers that there would be a continuing market for the fruits of American industrial progress after the war was over. President Harry S. Truman viewed the matter somewhat differently six years later, but his conception of the United States as the leader of technological progress was really the same. "The United States is preeminent among the nations in the development of industrial and scientific techniques," he declared in his Inaugural Address of January 1949. He conceded that "the material resources which we can afford to use for the assistance of other peoples are limited." But, he asserted, "our imponderable resources in technical knowledge are constantly growing and are inexhaustible.

"I believe that we should make available to peace-loving peoples the benefits of our store of technical knowledge," Truman declared, "in order to help them realize their aspirations for a better life. . . . Our aim should be to help the free peoples of the world, through their own efforts, to produce more food, more clothing, more materials for housing, and more mechanical power to lighten their burdens. . . . This should be a cooperative enterprise in which all nations work together. . . . It must be a worldwide effort for the achievement of peace, plenty, and freedom."

The passage of time and the involvement of the United States in serious international disturbances, such as the wars in Korea and Vietnam, did not abate the enthusiasm of Americans regarding their leadership in the world's progress. President John F. Kennedy gave voice to this enthusiasm in many speeches and writings, notably in his last speech, to have been delivered at Dallas on November 22, 1963. And in their book, *This U.S.A.*, a study of the 1960 census returns, Ben J. Wattenberg and Richard M. Scammon were as optimistic as anyone had ever been. "We face an America of new, newer, and newest things," they wrote in 1965, "a profusion and abundance of new things that will continue to transform life." They listed a number of inventions and discoveries they thought likely to occur, and declared that "all these things and more are possibilities to contend with in a still better America." And after conceding the difficulty of predicting the future, they concluded: "This much we all know: it will be an exciting future. One thing the nation cannot do is stand still, nor will it. Nearly every pointer from census statistics shows progress. We have just begun, and the best is yet to come. There is an America in the future that will make present accomplishments seem like the early adolescent flexings of a human body that will one day high-jump eight feet, run the hundred in eight seconds, and put the shot eighty feet. We, and along with us the rest of the world, are approaching a Golden Age."

The remarks quoted in the previous paragraphs support the assertion that the feeling of being in the forefront of progress has a long career in our history. However, all who have affirmed our leadership in progress have not been wholly satisfied with the progress we have made. Perennial doubts have been expressed, not about the essentially progressive character of the nation but about the direction in which it has moved.

Thus Evert A. and George L. Duykinck, for example, wrote in the *North American Review* in 1856 that "if there is one among the select intelligences of the Revolutionary era who may be justly considered as a representative mind, it is [Benjamin] Franklin." But, they hastened to say, "there never was an intellectual pioneer whose ideal was so thoroughly based upon use and so little cognizant of beauty. Science, indeed, might anticipate new and brilliant triumphs from such a votary, but Poetry folded her wings in despair, and Philosophy could find no scope, under his material wisdom, except for domestic economy and prudential aphorisms." It was the triumph of Franklin's philosophy of life, they asserted, that it laid the foundations of American prosperity; but it was also the continued and extreme influence of "this same utilitarian devotion and mercenary hardihood that now keeps the heart and mind of the country on a mechanical level, isolates the votaries of independent thought and frugal art, exalts handwork above wit, makes the intellectual harvest mean, and postpones the advent of strong, original, and universally recognized men of creative genius and fancy."

Many have agreed with the brothers Duykinck. Thoreau in the 1840s was almost rabid on the subject of progress, an idea, in his view, that was all the more dangerous for being so attractive. (Thoreau's strictures are considered in more detail below.) Henry George in the powerful pages of *Progress and Poverty* tried to remind his contemporaries of what most of them probably wanted to forget: that narrow technological progress had been accompanied, in America, by the increase of poverty and misery, and that there was a real question in 1879 whether the total change had been for the better or for the worse. Herbert Croly a generation later — in the midst of the ferment of the Progressive Era — also had serious doubts whether the country was headed in the right direction. Like many others at the time, he was certain that it could go right, that it could progress, but he was not sure that it would.

These were natives who called in question America's leadership of the world's (mainly technological) progress. A large number of foreign commentators from about the Civil War on also charged, in one way or another and more or less stridently, that the United States was moving very quickly but that the direction of the movement was not clearly desirable, if desirable at all. America was said by a host of visitors to be the land of Mammon and Moloch, to be a society with wholly materialistic values, obsessed with change for its own sake, rotten, as D. H. Lawrence put it, before it was ripe *("L'Amérique était pourri avant d'être mure")*.

Lawrence, in fact, in his *Studies in Classic American Literature* (1923), took the same critical view of the influence of Franklin as the Duykincks had taken sixty years or so before. He spoke of the obsession, as he viewed it, of Americans with their machines, and compared them — how many made the same comparison in after years! — to rats in a cage, running endlessly around and around, without rest or purpose.

Others, both natives and visitors, also

Courtesy, Karl Hubenthal, Los Angeles "Herald-Examiner"

"One of our systems is not 'Go'," Hubenthal, 1967

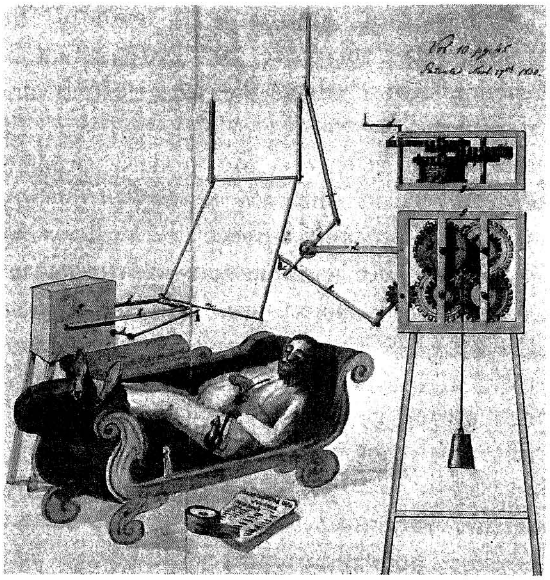
used mechanical analogies to criticize what they called America's naïve faith in its machines. "There is no easy road to peace," wrote educator Nathaniel Peffer in 1933. "The liberal reliance on treaties and international machinery is part of the deep-seated American faith in mechanical contrivances in all human situations." Charles B. Marshall had much the same complaint in 1952. "Some of the popular ideas derived from science reflect this same [excessive] material optimism," he said. "I think these are due not so much to the leaders of science themselves as to the popular interpreters of scientific achievement. From them we get the notion that cumulative knowledge can solve anything and that every problem is by definition solvable." And sociologist Morton Clurman put it succintly in an article in *Commentary* in 1953, as he bewailed "the endemic conviction of twentieth-century man that machines can do everything for him — including thinking."

Dwight Macdonald went even further in 1953 in discussing the popular belief in science. "The masses are less confident, more awed in their approach to science," he wrote, "and there are vast lower strata of science fiction where the marvelous is untrammeled by the limits of knowledge. To the masses, science is the modern *arcanum arcanorum*, at once the supreme mystery and the philosopher's stone that explains the mystery." He emphasized the perils involved in this conception. "Taken this way, science gives man mastery over his environment and is beneficent. But science itself is not understood, therefore not mastered, therefore terrifying because of its very power. Taken *this* way, as the supreme mystery, science becomes the stock-in-trade of the 'horror' pulp magazines and comics and movies. It has got to the point, indeed, that if one sees a laboratory in a movie, one shudders, and the white coat of the scientist is as blood-chilling a sight as Count Dracula's black cloak." [For another discussion of our practical ingenuity and inventiveness, see Ch. 1: NATIONAL CHARACTER.]

2. AMERICAN SCIENTIFIC PROGRESS

MISCONCEIVED AND MISDIRECTED or not, American scientific and technological progress has been remarkable. For instance, in listing the world's 338 most important inventions, a recent issue of the *World Almanac* credited 187 of them to Americans. Even allowing for a certain amount of chauvinism, the figure is impressive. One invention alone — Eli Whitney's cotton gin — may have gone far to establish the popular faith in science and invention. But there are other dramatic examples, too, ranging in size from the safety pin to the submarine.

Whitney's cotton gin, which dates from 1793, made it possible for one man to clean 50 pounds of cotton a day as against 1 pound by hand. When the machine was later improved and run by water or steam power, a single operator's output was raised to 1,000 pounds a day. The nation's cotton production reflected this extraordinary in-



National Archives

An 1830 patent drawing for a gear-driven fan

crease in efficiency. The annual export of cotton in 1791 was 200,000 pounds; by 1807 it was 64 million pounds.

The invention produced perhaps the first but by no means the last revolution in American agriculture. An advance comparable to the cotton gin was Cyrus McCormick's reaper (1831), which made possible the harvesting of the great prairie grain fields that feed much of the United States and a good part of the world besides. Of almost equal importance was John Deere's steel plow, invented in 1837. Jethro Wood had patented an iron plow — after a design of Thomas Jefferson — in 1819, and it worked well in the sandy soils of the East. But the soil of what was then called the West — Illinois, Indiana, and Wisconsin — was far different. Farmers said that it seemed like a combination of tar, mud, and molasses. The sticky soil clung to iron plows, and many changes in their shape were proposed but with no results. Deere, a young blacksmith, got the idea that steel rather than iron would do the job, and he made a plow out of a discarded circular saw blade. With it he plowed twelve smooth, straight furrows in a neighbor's field without having to stop once to clean his blade. Other neighbors took the plow and kept going up and down the field to make sure there was no trick to it. Deere sold his first plows for $10 apiece and was soon selling as many as he could make at his new factory in Moline, Illinois, where the main John Deere plant still is.

In 1790 approximately 90 percent of Americans were engaged in agriculture; today, less than 5 percent are so engaged. This extraordinary statistic, which goes far to explain America's present power and influence in the world, could not have been achieved if agricultural revolutions had ceased with Deere and McCormick in the 1830s. In fact, remarkable changes have occurred very recently. As late as 1963 some 60,000 persons were needed to harvest the annual California tomato crop, which provides most of the nation's supply in the winter months. By 1967, after the invention of a harvesting machine and the creation, by careful breeding, of a tomato variety that could be efficiently harvested by it, the number of workers needed to pick the crop fell by 80 percent. Experimental machines for harvesting other vegetables and (a more difficult problem) fruits such as oranges, grapefruit, and cherries are also being tested at the present time.

Radical changes occurred as a result of technological advances in many fields besides agriculture. Elias Howe's sewing machine helped to create a world in which good, cheap, and reasonably fashionable clothes could be bought by everyone, and in which the spinning wheel — that ancient symbol of femininity — became a curiosity almost overnight. (Howe's machine, the first successful one, worked and he made a fortune; a larger fortune was made by Isaac M. Singer, who was a promotional rather than a mechanical genius. Singer was the first man in history to spend $1 million for advertising, and when he died in 1875 he left $13 million.)

Ottmar Mergenthaler was born in Germany and came to the United States in 1872, at the age of eighteen. Employed by a cousin in a Baltimore machine shop, he became fascinated by the problem of mechanizing the tedious job of typesetting, and in 1884 he produced his linotype. The machine fostered a dramatic expansion of all fields of publishing and a rapid increase in literacy not only in this country but also in Europe. The first fruits of Mergenthaler's invention were the newspaper wars of the 1890s, the tabloids of the great cities, and the phenomenon known as "yellow journalism." But the modern paperback revolution and all it entails in the way of culture for the masses may also be traced to his door.

Until the 1850s there were few buildings in the world that were more than six stories high for the simple reason that people had to walk upstairs, and six flights was about the limit of endurance for domestic and business purposes. Elisha Otis, a Vermont inventor, changed all that when he patented the first safety elevator in 1852. Orders were few until May 1854 when, at the Crystal Palace Exhibition in New York City, he demonstrated his device by riding the platform high into the air and ordering the rope cut. The elevator started to fall, the crowd screamed, the safety device held, and Otis was in business. The direct result was the skyscraper, which came along only a few years later, and with it air pollution, crowded sidewalks, traffic jams, and our whole modern urban way of life.

Samuel F. B. Morse's telegraph (1837) and Alexander Graham Bell's telephone (1876) had equally revolutionary effects in almost every sphere of our lives. Perhaps the effects were even more striking. Not only did the telegraph and telephone fundamentally change our ways of waging war, doing business, and making love, but they also made our daily lives safer, allowed for centralization of many public services (including government itself), made possible the expansion over great distances of public and private functions, and — a much smaller but nonetheless poignant change — put an end to letterwriting as an art.

Until a hundred years ago most people on earth spent half of their lives in darkness — two-thirds of their lives in winter. It is hard to imagine what life was like in those circumstances, but we get some idea when we read the joyous poems about spring of the old poets. Spring meant not only warmth and the renewal of vegetation, not only the beauty and freshness of reviving nature. It also meant longer days and shorter nights, long evenings and early dawns.

Mankind has had devices for overcoming darkness for thousands of years. For most of that time, fire — in a fireplace or an outdoor bonfire, at the end of a torch or candle, or in an oil or gas lamp — had to suffice. But chemical sources of light were expensive and dangerous, and most people could afford them only on special or ceremonial occasions. Thomas Alva Edison gave light to all with his invention of the incandescent lamp. Hardly any discovery in the history of the world has done so much to change our daily — or perhaps one should say our nightly — lives.

Scores of other important inventions poured from Edison's fertile brain, not the least of which was the phonograph, which brought the sound of music to the multitudes. However, it is not to Edison but rather to Lee De Forest that we owe the triode or vacuum tube, the basis of wireless telegraphy and of modern radio and television. Actually, De Forest had little conception of what he had made, and it was the public itself that discovered the entertainment value of radio and television. But the public could never have made its discovery if De Forest had not made his first.

Three Bell Telephone Laboratory scientists took the next great step forward toward what has now come to be called the communications industry — an industry that to all intents and purposes did not exist two generations ago, but that now affects our lives at every point. Their names were John Bardeen, Walter Brattain, and William Shockley; in December 1947 they invented the transistor (for which they received a Nobel Prize in 1956). Transistors not only led to across-the-board miniaturization of electronic equipment but they also made feasible the giant second- and third-generation computers of our own time. The effects of the computer have only now begun to show, and it is clear that the major changes that it will bring about are still to come. But these changes are already sweeping enough to warrant calling our own era the Second Industrial Revolution.

In the spring of 1900 the Wright brothers, Wilbur and Orville, wrote to the Weather Bureau asking where, in the United States, there were places with constant wind and slopes free of trees. The Bureau named Kitty Hawk, North Carolina, among others. In reply to a further inquiry, the manager of the weather station at Kitty Hawk reported that "the beach here is about one mile wide, clear of trees or high hills, and extends for nearly sixty miles, same conditions. The wind blows mostly from the north and northeast September and October." This was perfect, for the Wrights wanted to glide, and glide they did.

But they discovered soon enough that gliding was not enough, that it would never satisfy them. They built new and better gliders and then, in March 1903, took their largest and best back to Kitty Hawk. It was powered with a motor, and they were really ready to fly. A telegram to their father, sent on December 17 of that year, recorded their achievement: "Success four flights Thursday morning all against twenty-one-mile wind started from level with engine power alone average speed through air thirty-one miles longest 59 seconds inform press home Christmas."

Other men had experimented with flight before the Wrights, and Europeans would make the greatest advances during the next two or three decades. But the Wrights were the first; as the plaque on their Kitty Hawk plane in the Smithsonian says, they "discovered the principles of human flight . . . taught man to fly, and opened the era of aviation." But they were wrong about one thing. They were sure, up until 1914, that they had introduced into the world, as Orville wrote in 1917, "an invention which would make further wars practically impossible. . . . We thought governments would realize the impossibility of winning by surprise attacks, and that no country would enter into war with another when it knew it would have to win by simply wearing out the enemy."

All of these inventions and technological advances — and many more could be mentioned, among them George Westinghouse's air brake (1869) and George Eastman's Kodak (1888) — pale to insignificance, important as they are, compared to the massive changes that will eventually be brought about as a result of the modern power revolution.

Human life on earth depends on energy. This has always been so and will always be so. For almost a million years man got along on the energy of his own body and on that of animals. A few hundred years ago he discovered how to use the solar energy stored in fossil fuels. This was a revolutionary change of the utmost importance; among other things it allowed him to triple his numbers within the short space of a couple of centuries. But as his dependence on fossil fuels has increased, his knowledge of the essentially limited nature of such sources of energy has also increased. All of the coal and oil and natural gas on earth will be gone within a century or two — at least within the foreseeable future. If that were to happen without man's having discovered any energy source as a replacement,

Courtesy, C. D. Batchelor, New York "Daily News"

the result would almost certainly be the death by starvation of one-half to two-thirds of the human race — perhaps as many as two or three billion people — and it might mean the end of the race itself.

What man needs — what he has always needed — is an inexhaustible source of energy. There are age-old dreams of such a treasure: the perpetual motion machine, various magical devices, the tapping somehow (the way, of course, not specified) of the divine energy. Finally the dream came true with the discovery of atomic energy, or, to be more precise, nuclear energy. (Atomic energy comes from uranium, the amount of which is sharply limited. Nuclear energy comes from water and rocks. There is enough of them to last man for the rest of time.)

All of the work is not done yet; the achievement of Enrico Fermi and his associates in producing the first self-sustaining chain reaction at the University of Chicago in December 1942 was only a first timid step; and the explosion of the first atomic bomb took man very little farther forward, if it did not take him back.

Most of those who were on the desert lands of New Mexico on July 16, 1945, knew what that explosion meant. It occurred at 5:30 in the morning. The War Department news release recorded that "darkening heavens, pouring forth rain and lightning immediately up to the zero hour, heightened the drama. . . . Dr. Oppenheimer, on whom had rested a heavy burden, grew tenser as the last seconds ticked off. He scarcely breathed. He held onto a post to steady himself. For the last few seconds he stared directly ahead and then when the announcer shouted 'Now' and there came this tremendous burst of light followed shortly after by the deep growling roar of the explosion, his face relaxed into an expression of tremendous relief. Several of the observers back of the shelter to watch the lightning effects were knocked flat by the blast.

"The effects could well be called unprecedented, magnificent, beautiful, stupendous, and terrifying. . . . The whole country was lighted by a searing light with an intensity many times that of the midday sun. It was golden, purple, violet, gray, and blue. It lighted every peak, crevasse, and ridge of the nearby mountain range with a clarity and beauty that cannot be described. . . . Thirty seconds after, the explosion came, the air blast pressing hard against the people and things, to be followed almost immediately by the strong, sustained, awesome roar which warned of doomsday and made us feel that we puny things were blasphemous to dare tamper with the forces reserved to the Almighty."

Our faith in American ingenuity, then, has ample basis in fact. But, curiously enough, nagging doubts remain. The feeling is shared by many that America has not produced much in the way of important and original scientific *ideas,* but instead has

Library of Congress

"Is this a time for sleep?"; etching, c. 1830

only applied the ideas of other men of other nations. Thus, for example, Oliver Evans, in the late eighteenth century in Pennsylvania, proposed a plan for a completely automated flour mill. Grain was poured in at one end and by means of gravity flow, Archimedes screws, and conveyor belts, was carried from one processing point to another until the finished flour was bagged at the other end. It was a marvelous machine, and it really worked; but the trouble was that there was nothing new in any of the parts, only in the way they were put together. Thomas Jefferson went as far as to assert that Evans should not receive a patent for his device since its constituent parts were as old as the Greeks.

According to this view the truly innovative side of American ingenuity, all the way from Evans, through meat-packing (the first instance of an overhead assembly line), to Henry Ford and, indeed, to the Manhattan and Apollo projects of our own day, has been in the organization of plant and equipment and the technological rationalization of human work, rather than in the discovery of new theories and techniques. And it is a fact that the United States continues to import, in large numbers, scientists and engineers who have received their theoretical training and have done their original work in other countries.

There is much truth in this criticism. There is no doubt that America is better known for its "inspired tinkerers" — men like Robert Fulton and Edison and Ford and the Wright brothers — than for its "pure" scientists. America is first in the world for "know how," but very far from first for "know that." And sometimes we even try to do and make *things* before we know much about *theories.*

A 1964 report of a scientific committee chaired by Barry Commoner reviewed the events leading up to the Apollo Project that was established by President Kennedy's announcement, on May 25, 1961, that "this nation should commit itself to achieving the goal, before this decade is out, of landing a man on the moon and returning him safely to earth." The report pointed to the fact that the procedure was "seriously at variance with important precepts of scientific experimentation and technology"; for the decision to embark on the program was, as the report emphasized, primarily a political one and only secondarily a scientific or technological one. The result was a reversal of the traditional sequence, "so that a program for a particular technological achievement has been committed, even as to the date of its accomplishment, in advance of the orderly acquisition of the related basic knowledge." One result of this haste, of course, was the tragic fire in the Apollo capsule in January 1967, which caused the deaths of three astronauts.

Nevertheless, America has achievements in pure science of which it can be proud. Benjamin Franklin was a greater politician than a scientist, but his scientific work, for which he gained his first European reputation, is not to be despised; and on his bust of Franklin the French sculptor Houdon inscribed this motto by Turgot: *Eripuit coelo fulmen sceptrumque tyrannis* ("He snatched the lightning from heaven and the scepter from tyrants").

Joseph Henry made many important discoveries in the new science of electricity during his long career as a teacher and researcher and as the first secretary of the Smithsonian Institution. He discovered the law of proportion between electromotive force and coil resistance, and his powerful short-coil magnet of 1829 is essentially the one used in modern generators and electric motors. He discovered electromagnetic induction independently of Michael Faraday, but Faraday published first. He recorded the action of radio waves in 1842. He studied sun spots and in 1844 presented a paper foreshadowing the principle of the conservation of energy. He continued to work at various projects until his death, at the age of eighty-one, in 1878. He was probably one of the ten or fifteen leading physicists of the earlier part of the nineteenth century.

Greater by far was Josiah Willard Gibbs. He began as an engineer, and when he was appointed to Yale's faculty in 1871 as a professor of mathematical physics, he had little more to his credit than a doctoral dissertation on gears and a patent on a railroad brake. But he soon found his subject, perhaps the most abstract and ephemeral and "pure" subject of all — change. He studied change all of his life, publishing some twenty monographs that set forth probably the most profound scientific truths ever to be formulated by an American.

Aristotle and the Greek physicists of his time had concluded that in a state of equilibrium everything must be motionless and at rest. Isaac Newton did not deny that when everything is at rest there is a state of equilibrium, but he pointed out that there can also be a state of equilibrium when there is motion. The solar system as a whole is in a state of equilibrium; but its parts — the planets, their satellites, the asteroids, and comets — all move. That was his prime example, but there were others, among them a machine with moving parts. The engine of a modern car has moving parts, but the engine as a whole is in equilibrium (unless there is something wrong with it, in which case it does not "run smoothly"). Newton's insight produced one of the great intellectual revolutions of all time and at the same time created the science of mechanics.

Gibbs's work was of equal magnitude. A state of equilibrium exists, he allowed, when all is at rest; a state of equilibrium can also exist when there is local motion (change of place). So far he agreed with Newton. But he added that there can also be a state of equilibrium when the parts or elements of a whole change their state or mode of existence — when water, for example, turns to steam, or when a gas turns into a solid at very low temperatures. He formulated the laws of chemical equilibrium and thereby produced another intellectual revolution that is comparable to Newton's. Newton had founded mechanics; Gibbs founded the science of physical chemistry, to which all other chemistries soon became subordinate. Within fifty years of his death, chemistry had pervaded most of the world's industry, and his work was used to explain such disparate phenomena as the action of volcanoes, the physiological processes in blood, the production of nitrates for explosives, and the manufacture of fertilizers. And four Nobel prizes were awarded for studies based directly on his results.

No U.S. scientist to the present day ranks with Gibbs, but there are others, nevertheless, of whom we can be proud. Charles Sanders Pierce is one of a half dozen eminent pure mathematicians — Oswald Veblen, the cousin of the eccentric and brilliant economist Thorstein Veblen is another — who were either born in the United States or did their important work here. Many of our Nobel Prize winners, for example, A. A. Michelson and Robert Millikan, were much more than inspired tinkerers. George Ellery Hale was first and foremost an organizer of science, but he was a good astronomer, too, and America's progress in this oldest and yet somehow newest of the sciences would have been slow without his tremendous efforts to find money and men. Matthew Fontaine Maury almost singlehandedly invented the modern science of oceanography — the investigation of the "inner space" that promises to produce more value for man than the highly publicized outer space, at least for decades and maybe centuries. More recently, U.S. biologists and medical researchers have done distinguished work on the theory of disease and on genetics. And there are many other fields, as well, in which Americans have made notable advances in pure as opposed to applied science.

Even taking into account these achievements, it may be that the criticism that the American spirit is fundamentally technological and not scientific still stands. Paradoxically, the best evidence for the position is the example of Willard Gibbs himself. The great American scientists have all been experimentalists — with the single exception of Gibbs. He was the only great theoretician the country produced in the nineteenth century, and he had no heir when he died at the beginning of the twentieth. Many people have wondered why.

"America has searched Gibbs's life," wrote science historian Mitchell Wilson in 1954, "as if to blame him for his difficult papers, his reluctance to be more aggressive in disseminating his truths in more useful forms, his inability to surround himself, like Agassiz, by hordes of devoted students. In the end, none of these are Gibbs's failures; they are flaws in America itself; and until America can produce another Willard Gibbs, it must continue to search itself. Gibbs is a measure of what American science can be. Was he simply a brilliant accident, or a prediction of what is to come? That this question has gone unanswered for half a century is itself a doleful, brooding answer."

3. GOVERNMENT SUPPORT OF SCIENCE

William Penn's First Frame of Government for Pennsylvania stated, as one of its principles, that "the governor and provincial Council shall erect and order all public schools, and encourage and reward the authors of useful sciences and laudable inventions." Charles J. Ingersoll observed in 1823 that "by the Constitution of the United States, it is the duty of government to promote the progress of science and the useful arts. Not one of the eleven new states has been admitted into the Union with provision in its constitution for schools, academies, colleges, and universities." And almost every U.S. President has affirmed and reaffirmed the government's responsibilities in this regard.

In one way and another, government — both federal and state — has been involved in scientific research since the beginning. During the first seventy years or so — up until the Civil War — such support was mainly indirect, through the Patent Office and similar agencies.

Patents, in fact, had been issued by the colonial and state governments prior to 1789, when the Constitution was ratified — the first being granted in 1641. The first federal Patent Office was under the Department of State, and Jefferson, who was secretary of state, insisted on personally reviewing every application. Not many patents were issued before 1800, partly because Jefferson and his successors did not have much time to examine the applications. To remedy this a system was inaugurated of granting patents to anyone who met certain formal requirements. The system, in operation until 1836, resulted in the issuance of many patents, but a large number were conflicting or were for "inventions" that were not really new. On July 4, 1836, Congress passed a law establishing the "examination" system of granting patents. The law has been changed many times but the system has remained essentially the same and has been adopted by a number of other countries.

At the present time patents are granted for the invention of "any new and useful process, machine, manufacture, or composition of matter, or any new and useful improvement thereof." Every word in that sentence has caused trouble for someone and has meant gains or losses of millions of dollars. Of particular interest are the words "new" and "useful." "New" does not necessarily mean new in the world, but only new in the United States; prior knowledge of an invention that is kept secret ordinarily will not stand in the way of granting a patent. "Useful" connotes that the invention must be directed to a useful purpose that can actually be accomplished. An invention that cannot do what it claims is not useful according to the definition; for this reason one could not obtain a patent on a perpetual motion machine; however, commercial practicability — another sense of "useful" — is not a requirement.

The only matter specifically excluded from the field of patentable inventions is the application of fissionable material or atomic energy to atomic weapons. This was excluded by the Atomic Energy Act of 1954.

For many years an apocryphal story has circulated among patent lawyers and others to the effect that the U.S. commissioner of patents once proposed that the Patent Office be closed for the reason that all the patents that needed to be issued had already been issued. The story is not true, but grounds for it may be found in Commissioner Henry L. W. Ellsworth's report for 1844, which stated that "the advancement of the arts, from year to year, taxes our credulity and seems to presage the arrival of that period when human improvement must end." The report of another commissioner for the year 1853 referred to a similar feeling that the increase of business in the Patent Office from year to year could not go on forever. "Some find it difficult to conceive," wrote Commissioner Hodges, "that this flood of discoveries and improvements is still to maintain its progress. They look for a falling off and doubt whether there is room for the continued exercise of inventive genius." However, the "flood" did continue, and it continues to this day — as in fact Hodges anticipated when he wrote, later on in his report, that "every step taken, instead of bringing us nearer to the close of our career, does but open up new scenes to explore and prepare the way for new triumphs." In 1836, when the flood of patents had necessitated a new law to deal with them, the United States was granting about 600 patents a year. In recent years, the number has exceeded 50,000 annually.

Up until 1945 U.S. government support of scientific research was greatest during wartime, when more or less total mobilization of the country's resources called for investment in new ideas as well as in armies and material. A good deal of naval research was done for the government during the

Courtesy, Herblock, "The Washington Post," 1957

"Dear boy, where have you been keeping yourself?"

Civil War, and the ironclad *Monitor* was one notable result. (The U.S. Navy, consisting mainly of wooden ships in 1860, was almost completely armored by the end of the century.) World War I brought another spate of government-supported research, not only in conventional tools of war but also in aircraft and in chemical weapons. However, the Wright brothers had been largely unsuccessful in their attempt to get the government to take a strong position in aircraft research until the war broke out, and after it was over, government-supported research lagged again. In 1940 the nation's total spending for "research and development" (R&D) is estimated to have been less than $350 million, of which the federal portion was about $74 million. This was only .03 percent of the gross national product, and the federal contribution was about .08 percent of the federal budget.

The rate of growth of such expenditures during the next twenty-five years was nothing short of spectacular. By 1962-1963 the nation's total expenditures for R&D had risen to $16.4 billion, of which the federal government provided $12.2 billion. This total was close to 3 percent — a hundredfold increase — of the gross national product, and the federal contribution was approximately 14 percent — or 175 times what it had been — of the federal budget.

Only a small proportion of this vast sum of money is spent for what might be called "basic research." Billions of dollars are spent every year in modern America for "development" — the translation of existing knowledge into hardware, gadgets, techniques, or new material. In general, such efforts are the function of engineers, and their nearly ceaseless activities account for the constant stream of "new" soaps, appliances, cars, and the like. Development is estimated to account for nearly 70 percent of R&D expenditures at the present time.

Something more than 20 percent of the total is spent for what might be called "applied research" — the quest, as science writer Daniel Greenberg wrote in 1967, "for a new understanding that is specifically needed to make possible a new development." Much space research would fall in this category, and some industrial research. Such efforts usually involve more science than engineering, but the two often merge.

Basic research is the quest for "fundamental knowledge [again according to Greenberg], regardless of the purpose to which it might be applied." Such efforts are carried out mainly by scientists, not engineers; the new knowledge may be used, but it need not be.

That indeed is the problem, as Greenberg and many others have seen it in the years since 1945. "The basic researcher," he wrote, "is not primarily, and perhaps not at all, concerned with utility. His objective is an understanding of fundamental phenomena, regardless of their utility. Therein lies the fundamental political dilemma of basic research in the United States. Patronage, public and private, comes to basic research for many reasons, but the strongest reason is a belief that utilizable results may ensue."

One could ask what other reason besides utility there should be for support of research — or for anything else. And, in a certain sense, of course, there *is* no other reason; things that are done for no use are *useless* and, thereby, not worth doing. Doubtless, however, the respondent to the question would want to draw a distinction between various kinds of use, just as he would wish to distinguish between various senses of the great American word "practical." Above all, he might want to criticize the modern American penchant for solving problems in isolation, while at the same time ignoring the larger problems of which they are a part. But such criticisms are more properly treated in the next section.

4. THE IMPACT OF TECHNOLOGICAL PROGRESS: THE TECHNOLOGICAL SOCIETY

"America is today in the midst of a transition," wrote Zbigniew Brzezinski, professor of political science at Columbia University, in 1968. "U.S. society is leaving the phase of spontaneity and is entering a more self-conscious stage; ceasing to be an industrial society, it is becoming the first technetronic one. This is at least in part the cause for much of the current tensions and violence."

Some of the changes to which Brzezinski referred are obvious enough. We have already mentioned the enormous change in agriculture, with the consequence that some 5 percent of the population feeds the other 95 percent — and much of the world besides. This means, of course, that the great majority of the population is freed from labor for subsistence and is therefore, at least potentially, a vast new leisure class. For Aristotle, for John Locke, even for Karl Marx only a century ago, this change would have been almost inconceivable and would have been more important than anything else that has happened since the beginning of human history. Maybe it is just that.

Doubtless, the dramatic changes in food production must be taken with a small grain of salt. When more than three-quarters of the population lived on farms, then inevitably a much greater proportion of agricultural products was consumed there and never found its way into the statistics. The mechanization of farms had a similar effect. Animals, which supplied most of the power for nineteenth-century farmers, ate a considerable part of the hay, rye, oats, corn, and so forth that they helped produce; now, the farmers' "animals" — his tractors, cultivators, combines, and the like — "eat" oil and gasoline, and the agricultural products that used to be consumed by mules, horses, and oxen are consumed either directly or indirectly (after being converted into protein by beef cattle, pigs, and chickens) by human beings.

Nevertheless, even with these provisos, the story of America's progress in agriculture is still astounding, and indeed it is the wonder of the world. Simple statistics reveal the marvel brought about by chemical fertilizers, mechanical cultivation, hybrid seed, and so forth. In 1900, a farmer in the "black soil" districts of Illinois would have been happy to harvest 30-40 bushels of corn on an acre of land. As late as 1945, 60 bushels an acre was a good yield. In the 1960s, however, an acre of land in a fair year could be expected to produce upward of 125 bushels of corn that was, in addition, more nutritious (for cattle and pigs and chickens) than *any* corn grown in the United States in 1900.

Similar, if not quite so dramatic, changes have occurred in many industries; indeed, in some industries, the changes have been even more dramatic. This has been evident to observers for several generations. Thus in

1898, for example, Josiah Strong recorded the estimate (by "an excellent statistician") that "if the goods made in one year by the 3 million factory workers in the United States . . . had been made by hand, their production would have required the labor of 150 million persons; that is, the machine method may be considered, on the average, about fifty times as productive as the old hand method."

What is most striking about Strong's figures, of course, is that the entire population — men, women, and children — of the United States in 1898 did not add up to 150 million persons. The same point can be made by another set of figures. We sometimes regret the passing of the human telephone operator, that romantic personage to whom one addressed the now almost forgotten "Hello, Central!" Automatic relays can't tell you what's playing at the Bijou, where Mrs. Smith is if she doesn't answer her phone, or call the Fire Department because Aunt Minnie sees smoke behind the Johnson barn. However, in order to complete by hand the number of telephone calls made today, some 200 million operators would be required — or approximately twice the whole female population of the United States, including girl babies and old ladies.

Strong drew the obvious — and perennial — conclusion from all of this. "The immense increase of supply greatly stimulated demand and resulted," he declared, "in a remarkable elevation of the standard of living. With the rise of that standard, what at first were regarded as luxuries came to be considered conveniences or comforts, and were at length deemed necessities. There are those still living who remember when friction matches were a luxury."

Harlow Curtice, president of the General Motors Corporation, echoed Strong's sentiments — and went even further. "Continuing emphasis on change, on a better method and a better product, in other words, on progress in technology," he said in 1956, "has been the major force responsible for the growth and development of our country. . . . From this process of accelerating obsolescence by technological progress flow the benefits we all share — more and better job opportunities, an advancing standard of living — the entire forward march of civilization on the material side."

But what of the other side — the aesthetic, the spiritual side, as it may be called?

There is a persistent strain of American thought and writing that is strongly opposed, in one way or another, to progress and particularly to our devotion to progress. As has been said, Thoreau was probably the most radical nineteenth-century critic of the mystique of technological progress — although not really an effective one, for he was not widely read in his time. "It is with a certain coldness and langour that we loiter about the actual and so-called practical," he wrote in 1843. "How little do the most wonderful inventions of modern times detain us. They insult nature. Every machine, or particular application, seems a slight outrage against universal laws. How many fine inventions are there which do not clutter the ground?"

These remarks are to be found in the review of a strange book by J. A. Etzler, called *The Paradise within the Reach of All Men, without Labor, by Powers of Nature and Machinery.* Etzler was a devoted follower of Francis Bacon, William Godwin, the Marquis de Condorcet, Robert Owen, and others who believed that a utopia on earth might be realized through the application of science and technology to the old, thorny problems of human life. He concluded his book with a picture of what the world would be like if it were not for man's "ignorance, prejudice, and stupid adherence to custom."

"Thus is Paradise to be Regained," wrote Thoreau, "and that old and stern decree at length reversed. Man shall no more earn his living by the sweat of his brow. . . . In fact," Thoreau went on, "no work can be shirked. It may be postponed indefinitely, but not infinitely. Nor can any really important work be made easier by cooperation or machinery. Not one particle of labor now threatening any man can be routed without being performed. . . . You may begin by sawing the little sticks, or you may saw the great sticks first, but sooner or later you must saw them both."

Thoreau was just a "nut," it is sometimes said. But many others have concurred in his general derogation of American technological progress, if not in the specific terms he used to express it. Thus Dr. George M. Beard, for example, an expert on neurological ailments, complained in 1881 of the "unrhythmical, unmelodious, and therefore annoying, if not injurious" noises that troubled both his sleeping and waking hours. (What would he have had to say if he had lived in New York City in the 1960s!) Harvard President Dr. Charles W. Eliot reported in 1892 that many laborers felt that "the direction of machines is more exacting than old-fashioned handwork, and . . . the extreme division of labor in modern industries is apt to make the life of the operative or mechanic monotonous and narrowing." This was a charge, indeed, that was repeated over and over in the years to come.

Author Frederick Dwight's criticism was even more severe. "Commentators have declared," he wrote in 1908, "that the tendency of our development is toward a colorless and uninteresting civilization, devoid of highlights or any element of the picturesque." And he cited an example that has been cited many times since. "The average motorist of today [1908!] is an argument for the contention. During the reign of horse-drawn vehicles, no costumes were too carefully designed. Under the new regime, nothing is too ugly. Hatless and coatless or wrapt in linen dusters and huge veils, men and women are reduced to one uninspiring begoggled level. In place of the trim coachman, erect on his box, one sees a creature clad in dingy cap and cotton duster, sitting on the small of his back, and so sunken that the crown of his head is almost on a level with the shoulder of the person by his side."

In recent years, the charge against the automobile has involved more than merely aesthetic considerations, although it has not ceased to involve them, too. In the mid-1960s, which were marked by widespread attacks against the auto industry — most notable, perhaps, is that of Ralph Nader, whose *Unsafe at Any Speed: The Designed-in Dangers of the American Automobile* (1965) led to congressional investigations — Lewis Mumford excoriated not only the carmakers but also the American public's attitude toward them and their products. "The insolence of the Detroit chariotmakers and the masochistic submissiveness of the American consumer," he wrote in 1966, "are symptoms of a larger disorder: a society that is no longer rooted in the complex realities of an organic and personal world; a society made in the image of machines, by machines, for machines; a society in which any form of delinquency or criminality may be practised, from meretriciously designed motorcars or insufficiently tested wonder drugs to the wholesale distribution of narcotics and printed pornography, provided that the profits sufficiently justify their exploitation. If those remain the premises of the Great Society," he concluded, "we shall never be out of danger — and never really alive."

Many others have joined the chorus of dispraise in this century; humorist James Thurber was considerably less solemn than most. "Many people believe that it was a sad day indeed when Benjamin Franklin tied that key to a kite string and flew the kite in a thunderstorm," he wrote in 1937; "other people believe that if it hadn't been Franklin, it would have been someone else. . . . At any rate, it has come about that so-called civilized man finds himself today surrounded by the myriad mechanical devices of a technological world."

The attacks, of course, have not gone unanswered. Timothy Walker, as early as 1831, defended technology against Thomas Carlyle's indictment of "the mechanical philosophy." Frontiersman Davy Crockett visited the cotton mills of Lowell, Massachusetts, in 1835, and lauded many things he saw. U.S. Labor Commissioner Carroll D. Wright praised factory technology in 1882, declaring that "one of the inevitable results of the factory is to enable men to secure a livelihood in less hours than of old; this is grand in itself, for as the time required to earn a living grows shorter, our civilization grows up." City planners Daniel H. Burnham and Edward H. Bennett praised electric railroads in 1909, and added that "the rapidly increasing use of the automobile" would promote "good roads and [revive] the roadside inn as a place of rest and refreshment. With the perfection of this machine and the extension of its use, out-of-door life is promoted, and the pleasures of suburban life are brought within the reach of multitudes of people who formerly were condemned to pass their entire time in the city."

Other defenses are to be found. Henry Ford denied emphatically in 1928 that "machine production kills the creative ability of the craftsman. This is not true," he said. Instead, the machine demands that man be its master; it compels mastery more than the old methods did. "The number of skilled craftsmen in proportion to the working population has greatly increased under the conditions brought about by the machine." David E. Lilienthal, first director of TVA, saw other reasons for optimism. "A world of science and great machines is still a world of men," he wrote in 1944. "Our modern task is more difficult, but the opportunities for democratic methods are greater even than in the days of the axe and the hand loom." Art critic John A. Kouwenhoven emphasized in 1948 not so much the democratic opportunities as the freedom that America's "mechanized civilization" had always — not just in the twentieth century — afforded its people. And of course there have been many other recent eulogies of our progressive way of life.

Courtesy, Ross A. Lewis, "The Milwaukee Journal"

"Can't recall your name, but your face is familiar"

Nevertheless, the attacks on technology predominate, and the anxiety about it seems to increase with every passing year. Newton N. Minow, the young chairman of the Federal Communications Commission in 1961, charged that television had already become a "vast wasteland," in short, that this marvelous technological device was already being almost totally misused. (There was much scurrying about in the industry as the result of his speech, but television was not much changed a decade later.) O. W. Wilson made an eloquent plea in the same year for greater freedom for the police to use modern techniques to control crime, but others objected, also with eloquence, on the grounds that the newest devices would put an end to privacy altogether, not just for criminals but for everyone.

Rachel Carson, the next year, cried out against the use of technological devices for "controlling" nature on the grounds that they did not control it at all but merely destroyed it — and that man himself, whether he recognized it or not, was a part of nature and could not live without or outside of it. And a Senate Report on Urban Mass Transportation, also dated 1962, pointed to the fact that U.S. cities, largely as a result of technological advances in automobiles and in roadbuilding, were tangled in their own wheels and could no longer move — when movement had been the point of the advances in the first place.

Nor was that all. W. H. Ferry and Michael Harrington wrote in 1962 about the terrible problems that abundance — itself the fruit of technological progress — had created in the United States, not only for those who did not share in it (and they were, and are, many) but also for government. In the same year Harvard faculty members J. S. Dupré and W. E. Gustafson spoke of the conflict of interest between the public as a whole and the defense contractors who were doing business for the government at a nearly $100-billion-a-year rate. Jerome B. Wiesner, President Kennedy's chief science adviser, discoursed in 1963 on the difficulties encountered by science itself in an affluent society, and Professor Louis Lasagna outlined in the next year the difficulties faced by drug companies, as well as the public, in the development of new and more powerful drugs.

Journalist Eric Larrabee, in 1965, pointed to some of the problems of the "new leisure" — another result of technological advance. An editorial in 1965 in the *New Yorker* complained of the frightening consequences of the decision by the U.S. government to build a supersonic transport plane. A swath a hundred miles wide all across the United States would be made uninhabitable by this monstrous new machine, the editorial warned, citing it as an example of how technology had come to rule our lives.

Courtesy, Edward Kuekes, Cleveland "Plain Dealer"

"I love thy rocks and rills"; Kuekes, 1965

The year 1966 saw the publication of many more attacks, exposés, and the like (selections from all of the foregoing are reprinted in Vol. 18 of the ANNALS, but of course they represent only a sampling). The coal mines of western Pennsylvania, and of West Virginia and Kentucky, have been nearly exhausted by a century or more of mining by traditional methods. But much coal remains; the problem is to get it out of the ground at a reasonable cost. Strip mining was the technologist's answer — the use of gigantic machines, some as large as a four-story building, that tear up hillsides with the ease of a child playing in the sand. The coal is gotten out — but the land is left ugly and useless. Journalist Harry M. Caudill described the process and its grim effects in an article in the *New York Times* in 1966. Ecologists C. F. Powers and Andrew Robertson described another destructive process in an article in *Scientific American* in the same year. The Great Lakes are relatively young, as lakes go, and in the ordinary course of events would have a "lifespan" of a good many thousand years. But the course of events has not been ordinary. Lake Erie has aged 50,000 years in a century and may already have passed the point of no return. Lake Michigan, which is deeper, may still be saved — if the effort is made in time (by no later than about 1975). And, the two ecologists warned, Lakes Huron and Superior can also be destroyed if pollution is not controlled.

The country's supply of fresh water is not the only thing that is being polluted at a frightening rate; the world's air is also being polluted, and this is much more important. It is already unpleasant and very probably dangerous to breathe the air of some of our major cities, and the number of cities in which this is so will increase in the near future. But it is not only human lungs that are being affected. Man is spewing enormous amounts of carbon dioxide and other pollutants into the atmosphere every hour and day of the year — from his machines, his cars and factories and houses. The earth's atmosphere knows no national boundaries, and the air above the North and South poles already contains as much carbon dioxide as the air above Los Angeles, and that is probably more than at any time for thousands of centuries.

By the year 2000, if this process continues, the atmosphere will be so saturated with carbon dioxide that the so-called greenhouse effect will go into operation. The sun's rays, striking the earth's atmosphere from outside, will pass through it easily enough; however, the rays will not be able to escape when they bounce off the earth, but will instead be trapped between the earth and the saturated atmosphere, with the result that (as in a greenhouse) the temperature near the earth's surface will rise steadily and rather quickly. It will not take long for the temperature to rise high enough for the North and South polar ice to start melting. There is enough ice in the South polar icecap alone to raise the level of all the world's oceans by 100 feet or more. Approximately 2 billion human beings live in places that are less than 100 feet above sea level. This second flood, scientists warn, may be the last.

Mankind may not have to, or be able to, wait until the second deluge puts an end to his problems. The United States already possesses enough hydrogen bombs to kill every living thing on earth several times over, and probably so does the Soviet Union. Other weapons, the fruit of recent frantic research, could have the same doleful effect. And perhaps not even weapons — explosive, biological, chemical — will be necessary. The technologies involved in the saving of human lives have advanced much faster than the technologies involved in the limitation of human numbers, and the earth's population is therefore growing at what may be a catastrophic rate. Various estimates are available, but the most optimistic of them indicates that at least 5 billion humans will be alive in the year 2000, and, if the rate of growth continues, that at least 6 billion will be alive in 2050. That is nearly twice the present population of the earth, and the problem of feeding the 3 billion now alive is difficult enough. Technology may be able to find food for 6 billion eventually, but it appears that it will not be possible to find it fast enough. Half of the grandchildren and great-grandchildren of all persons now living may, therefore, starve to death.

The problems that technology presents us, some of which are outlined in the foregoing paragraphs, are hard and bitter. But humans have faced hard and bitter problems before. Can these be solved?

The ironic fact, of course, is that all can be solved — but that technology, which caused them in the first place, must do the job. The real difficulty, however, is not in the individual problems but in seeing and solving them all together. Heart transplants are a technological marvel of supreme interest and importance — but if fewer and fewer people die of heart disease, then starvation will come all the sooner for many of those who survive diseases that might have killed them a decade ago. The twin problems of aggressive nationalism and cheap atomic weapons *could be* solved by the creation of a worldwide, despotic super-state — but most people would probably not think that *solved* the problems. The problem of air pollution would be solved overnight if we shut down all the factories, threw away the keys of all the cars, and stopped burning coal, oil, and gas in our homes and factories. But a considerable proportion of the human race could not survive this, either, anymore than they could survive the great flood that may be coming.

Courtesy, Edward Kuekes, Cleveland "Plain Dealer"

"Belching Death"; Kuekes, 1949

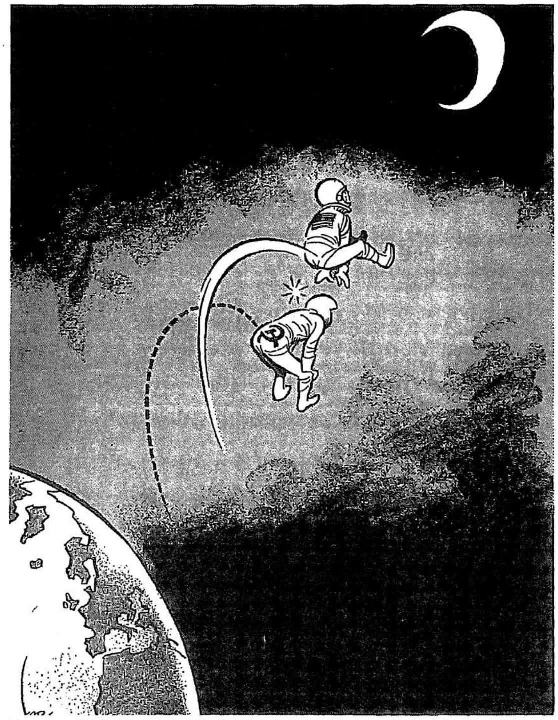
What is the answer? We cannot say; nor, perhaps, can any man say. It is at least true, on a lower level, that there is a deep ambivalence in most Americans about technological progress. Few of us do not experience an occasional nostalgia for the past, when life (as it sometimes seems) was simpler and somehow better understood. (It may not have seemed so understandable to the people who lived then.) At the same time, few of us would be willing to give up the "modern conveniences" that technological progress has made possible. Traffic jams are an annoying nuisance — but there is no more exhilirating feeling than to start out early on a bright morning in an automobile. The ringing of the telephone sometimes jangles our nerves — but life without it would be perilous for many persons, to say nothing of inconvenient and lonely. Machine-made cloth has allowed the majority, instead of the small minority, to dress well and comfortably — does anyone really want to go back to homespun? Television may be a wasteland — but it beguiles a weary hour. And though we often bewail the loss of the old, "homey" relationship with the family doctor, we are thankful for the modern "specialist" when serious illness strikes.

There are difficulties, to be sure. Something has to be done about car safety when 1,000 people a week die in automobile accidents. As Thurber put it in 1937, "With the disappearance of the gas mantle and the advent of the short circuit, man's tranquillity began to be threatened by everything he put his hand on." Americans have not yet wholly "grown up" to their technology; in certain respects we are still like children playing with complicated and dangerous toys that delight them but that they do not understand.

There are difficulties, too, in the "technologization" of modern life. No one really likes to be accused of wrongdoing by a computer, as when one of these machines charges us — or aids a revenue agent to charge us — with not paying the correct amount of taxes. The computer is "fair" in the sense that it treats all equally; but at the same time it has no "soul" and disregards the special circumstances that most of us feel ought to be taken into account. Indeed, we often have the impression nowadays that we have become just "numbers" in an impersonal, mechanized accounting system. This, of course, is unpleasant. Man is a gregarious animal. To paraphrase Aristotle's ancient dictum, the man who is able to live comfortably in the company only of machines is "either a beast or a god." We need human contact and warmth to remain human. Computers and the other mechanical aids to social order pay no attention to love.

However, 200 million plus Americans could not live at all in this country without modern technology. Without it, the social fabric would decay; grass (to take a famous warning of Herbert Hoover's out of context) would grow in the streets of a hundred cities; men, women, and children by the millions would starve and go unclothed and unsheltered; and life would once again become, as Thomas Hobbes put it long ago, "solitary, poor, nasty, brutish, and short."

We must live with technology and progress, then; we cannot live without it. And the great question for America's future in this regard is not whether technological progress will continue, for assuredly it will, but whether we can learn to endure the changes it will make in our lives with a degree of ease and grace. To that question no reasonable man can give a certain answer. As the French proverb puts it, *qui vivra, verra* — he who lives will see.



Courtesy, Karl Hubenthal, Los Angeles "Herald-Examiner"

"Leapfrog"; cartoon by Hubenthal, 1966