AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

150 YEARS • 1848-1998

SCIENCE AS A CRAFT INDUSTRY

ILLUSTRATION: ALLAN M. BURCH

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My grandfather John William was a blacksmith, working in a small ironworks in Yorkshire, in the north of England. With his own hands he forged boilers that were exported all over the world, bringing steam power to drive ships and start industrial revolutions in remote places. He was not much concerned with science. He was a skilled craftsman, still working in the old tradition of craft industry that started the first industrial revolution in England a hundred years earlier. Meanwhile, his contemporary Andrew Carnegie moved from Scotland to Pittsburgh and built ironworks of a different kind. Big Steel supplanted craft workshops. By the time John William retired at the beginning of the 20th century, the old craft industries in the north of England were dying. In the next generation, young boys who wanted to get ahead did not become blacksmiths. Many of them, like my father, moved south and went to college.

And still, the human heritage that gave us tool-making hands and inquisitive brains did not die. In every human culture, the hand and brain work together to create the style that makes a civilization. In every civilization, the skilled artificer has an honored place beside the scribe and the shaman. Our own civilization is no exception. During the first half of the 20th century, as the young people of the next generation forgot the skills of my grandfather, they learned new skills and started new industries. They built radio transmitters and receivers, microscopes and telescopes, motor bicycles and flying machines. They bred hybrid corn and new varieties of flowers and fruit. Each of these industries grew out of small beginnings and flourished as a craft industry before evolving into large-scale organization and mass production. The early years of the century were the golden age of radio and of flying machines, when inventors could build with their own hands machines that would change the world.

As we moved into the second half of the 20th century, it seemed that craft industries were dwindling. Mass production dominated the new technologies of television and synthetic materials and large-scale agriculture. Young people, it seemed, had only two choices, either to join the ranks of employees of big enterprises or to lose interest in technology altogether. The third alternative, to make a living as an artificer with a skilled craft, was no longer practical. But then, science emerged to fill the gap.

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*T. Kidder, *The Soul of a New Machine* (Little, Brown, Boston, 1981).

I remember vividly a scene from the 1960s, when young people were at their most rebellious and technology was most unpopular. Bare feet and outrageous behavior were the prevailing fashions among students. I happened to walk into a basement workshop at the bottom of the physics building at Cornell University. There I saw two students, dressed in the customary style, with bare feet and long, unkempt hair, building a cryostat for low-temperature experiments with liquid helium. This was not an ordinary helium cryostat that would take you down to 1 degree above absolute zero. This was a new type of cryostat, working with the rare isotope of helium, that would take you down to a few millidegrees above absolute zero. The students were exploring a new world and a new technology. The working volume of the cryostat was extremely small. It had to be surrounded with many layers of vacuum-tight insulation, and it had to be connected to the outside world by a network of tiny tubes and wires. The students were absorbed in putting this intricate maze of tubes and wires together. Their brains and hands were stretched to the limit. They had to be sure that every joint was tight, every wire was in exactly the right place. I do not remember their names. I do not know whether they stayed on at Cornell and became professional physicists. If they did, it is possible that one or both of them won a Nobel Prize 30 years later, when three Cornell physicists shared the prize for the discovery of superfluidity in the rare helium isotope. At the time when I saw them as students putting the apparatus together, they were not dreaming of Nobel Prizes. They were driven by the same passion that drove my grandfather, the joy of a skilled craftsman in a job well done. Science gave them their chance to build things that opened new horizons, just as their ancestors built ships to explore new continents.

During the last 50 years, science has given birth to a new golden age of craft industry. As science extends its reach, it needs new instruments that are increasingly delicate and precise, and it trains students and technicians to build them. Wherever experimental science is done, young men and women are learning to build instruments, using the new materials and new concepts that science has made available. And then, the crafts that were nurtured in the laboratory find uses in the world outside. The same young people launch start-up companies to manufacture and sell instruments to other users. And a new craft industry grows. Around every large center of scientific research we find a swarm of craft industries. Some of them outgrow their origins and become large-scale manufacturing enterprises.

Other small companies with newer crafts emerge to take their places.

One of the most important tools of modern science is the computer. The building of computers began as a craft industry. An unruly gang of mathematicians and engineers at the Institute for Advanced Study in Princeton worked under the supervision of John von Neumann, and other similar gangs built one-of-a-kind machines elsewhere. Tracy Kidder, in his book *The Soul of a New Machine*,* portrayed the spirit of a craft industry still surviving into the modern era. But the machine that Kidder described and the team of engineers who designed it did not survive. The machine was a failure and the team dissolved. A few years later, Seymour Cray and Danny Hillis, the last of the old breed of craftsmen manufacturing computers as independent entrepreneurs, admitted defeat. They could not compete in the marketplace with the big producers. The craft-industry era of computer manufacture is now coming to an end.

STOCK MONTAGE

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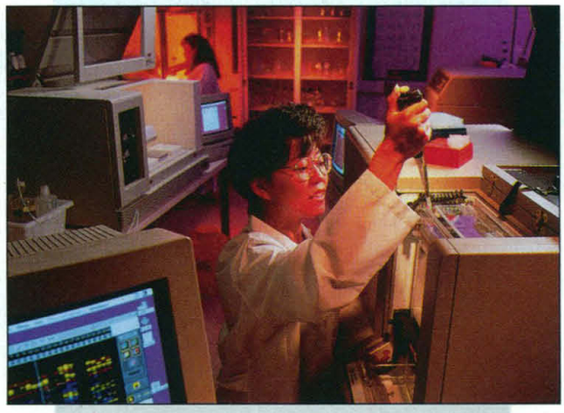

WILLIAM TAUFIC/THE STOCK MARKET

But the computer gave birth to a larger craft industry that is still flourishing, the software industry. Computer software began as a tool of science and later spread to all areas of industry and commerce. Wherever serious computing was done, young people learned to write software and to use it. In spite of the rise of Microsoft and other giant producers, software remains in large part a craft industry. Because of the enormous variety of specialized applications, there will always be room for individuals to write software based on their unique knowledge. There will always be niche markets to keep small software companies alive. The craft of writing software will not become obsolete. And the craft of using software creatively is flourishing even more than the craft of writing it. The availability of software and the skill to use it gave rise to a whole constellation of new craft industries, from desktop publishing to computer-aided design and manufacturing. A large fraction of the small businesses now operating owe their existence to software that in turn owes its existence to science. This is true even of the more frivolous applications such as computer-aided dating services and computer-aided horoscopes.

Another constellation of craft industries grew out of biology. My youngest daughter, needing to improve her financial situation before entering medical school, worked for a small company preparing DNA libraries. The libraries are collections of standardized samples of DNA. They are sold to laboratories engaged in genetic research or medical diagnosis. This is a typical craft industry of the modern age. The libraries made by a specialized company are cheaper and more reliable than libraries made by the users for themselves. The employees of the company take pride in their work, of which quality control is the most important part. They ship their libraries all over the world, like the Yorkshire boiler-makers a hundred years earlier. My daughter enjoyed the work and showed a talent for it, helped by a few of her great-grandfather's chromosomes.

Science is constantly changing, and the craft industries that it engenders must change too. Technologies rise and fall, and fashions come and go. In the future, many of the small enterprises of today will be consolidated, and new small enterprises will have to find different niches to fill. Today the most successful craft industries are concerned with software and biotechnology. The craft industries of the future might be concerned with neurophysiology or ecology, with technologies not yet invented or with sciences not yet named. Two facts of life will not change. Science will continue to generate unpredictable new ideas and opportunities. And human beings will continue to respond to new ideas and opportunities with new skills and inventions. We remain tool-making animals, and science will continue to exercise the creativity programmed into our genes.

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ILLUSTRATION: TERESE WINSLOW