THE PENCIL

A History of Design and Circumstance

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1/ What We Forget

Henry David Thoreau seemed to think of everything when he made a list of essential supplies for a twelve-day excursion into the Maine woods. He included pins, needles, and thread among the items to be carried in an India-rubber knapsack, and he even gave the dimensions of an ample tent: "six by seven feet, and four feet high in the middle, will do." He wanted to be doubly sure to be able to start a fire and to wash up, and so he listed: "matches (some also in a small vial in the waist-coat pocket); soap, two pieces." He specified the number of old newspapers (three or four, presumably to be used for cleaning chores), the length of strong cord (twenty feet), the size of his blanket (seven feet long), and the amount of "soft hardbread" (twenty-eight pounds!). He even noted something to leave behind: "A gun is not worth the carriage, unless you go as a huntsman."

Thoreau actually was a huntsman of sorts, but the insects and botanical specimens that he hunted could be taken without a gun and could be brought back in the knapsack. Thoreau also went into the woods as an observer. He observed the big and the little, and he advised like-minded observers to carry a small spyglass for birds and a pocket microscope for smaller objects. And to capture the true dimensions of those objects that might be too big to be brought back, Thoreau advised carrying a tape measure. The inveterate measurer, note taker, and list maker also reminded other travelers to take paper and stamps, to mail letters back to civilization.

But there is one object that Thoreau neglected to mention,

one that he most certainly carried himself. For without this object Thoreau could not have sketched either the fleeting fauna he would not shoot or the larger flora he could not uproot. Without it he could not label his blotting paper pressing leaves or his insect boxes holding beetles; without it he could not record the measurements he made; without it he could not write home on the paper he brought; without it he could not make his list. Without a pencil Thoreau would have been lost in the Maine woods.

According to his friend Ralph Waldo Emerson, Thoreau seems always to have carried, "in his pocket, his diary and pencil." So why did Thoreau—who had worked with his father to produce the very best lead pencils manufactured in America in the 1840s—neglect to list even one among the essential things to take on an excursion? Perhaps the very object with which he may have been drafting his list was too close to him, too familiar a part of his own everyday outfit, too integral a part of his livelihood, too common a thing for him to think to mention.

Henry Thoreau seems not to be alone in forgetting about the pencil. A shop in London specializes in old carpenter's tools. There are tools everywhere, from floor to ceiling and spilling out of baskets on the sidewalk outside. The shop seems to have an example of every kind of saw used in recent centuries; there are shelves of braces and bins of chisels and piles of levels and rows of planes—everything for the carpenter, or so it seems. What the shop does not have, however, are old carpenter's pencils, items that once got equal billing in Thoreau & Company advertisements with drawing pencils for artists and engineers. The implement that was necessary to draw sketches of the carpentry job, to figure the quantities of materials needed, to mark the length of wood to be cut, to indicate the locations of holes to be drilled, to highlight the edges of wood to be planed, is nowhere to be seen. When asked where he keeps the pencils, the shopkeeper replies that he does not think there are any about. Pencils, he admits, are often found in the toolboxes acquired by the shop, but they are thrown out with the sawdust.

In an American antique shop that deals in, among other things, old scientific and engineering instruments, there is a grand display of polished brass microscopes, telescopes, levels, balances, and scales; there are the precision instruments of physicians, navigators, surveyors, draftsmen, and engineers. The shop also has a collection of old jewelry and silverware

and, behind the saltcellars, some old mechanical pencils, which appear to be there for their metal and mystery and not their utility. There are a clever Victorian combination pen and pencil in a single slender, if ornate, gold case; an unassuming little tube of brass less than two inches long that telescopes out to become a mechanical pencil of twice that length; a compact silver pencil case containing points in three colors—black, red, and blue—that can be slid into writing position; and a heavy silver pencil case that hides the half-inch stub of a still-sharpened yellow pencil of high quality. The shopkeeper will proudly show how all these work, but when asked if she has any plain wood-cased drawing pencils that the original owners of the drafting instruments must certainly have used, she will confess that she would not even know what distinguished a nineteenth-century pencil from any other kind.

Not only shops that purport to trade in the past but also museums that ostensibly preserve and display the past can seem to forget or merely ignore the indispensable role of simple objects like the pencil. Recently the Smithsonian Institution's National Museum of American History produced "After the Revolution: Everyday Life in America, 1780–1800," and one group of exhibits in the show consisted of separate worktables on which were displayed the tools of many crafts of the period: cabinetmaker and chairmaker, carpenter and joiner, shipwright, cooper, wheelwright, and others. Besides tools, many of the displays included pieces of work in progress, and a few even had wood shavings scattered about the work space, to add a sense of authenticity. Yet there was not a pencil to be seen.

While many early American craftsmen would have used sharp-pointed metal scribers to mark their work, pencils would also certainly have been used when they were available. And although there was no domestic pencil industry in America in the years immediately following the Revolution, that is not to say that pencils could not be gotten. A father, writing in 1774 from England to his daughter in what were still the colonies, sent her "one dozen Middleton's best Pencils," and in the last part of the century, even after the Revolution, English pencils like Middleton's were regularly advertised for sale in the larger cities. Imported pencils or homemade pencils fashioned from reclaimed pieces of broken lead would have been the proud possessions of woodworkers especially, for carpenters, cabinetmakers, and joiners possessed the craft skill to work wood into a form that could hold pieces of graphite in a

comfortable and useful way. Not only would early American woodworkers have known about, admired, wanted to possess, and tried to imitate European pencils, but also they would have prized and cared for them as they prized and cared for the kinds of tools displayed two centuries later in the Smithsonian.

These stories of absence are interesting not so much because of what they say about the lowly status of the wood-cased pencil as an artifact as because of what they say about our awareness of and our attitudes toward common things, processes, events, or even ideas that appear to have little intrinsic, permanent, or special value. An object like the pencil is generally considered unremarkable, and it is taken for granted. It is taken for granted because it is abundant, inexpensive, and as familiar as speech.

Yet the pencil need be no cliché. It can be as powerful a metaphor as the pen, as rich a symbol as the flag. Artists have long counted the pencil among the tools of their trade, and have even identified with the drawing medium. Andrew Wyeth described his pencil as a fencer's foil; Toulouse-Lautrec said of himself, "I am a pencil"; and the Moscow-born Paris illustrator and caricaturist Emmanuel Poiré took his pseudonym from the Russian word for pencil, *karandash*. In turn, the Swiss pencil-making firm of Caran d'Ache was named after this artist, and a stylized version of his signature is now used as a company logo.

The pencil, the tool of doodlers, stands for thinking and creativity, but at the same time, as the toy of children, it symbolizes spontaneity and immaturity. Yet the pencil's graphite is also the ephemeral medium of thinkers, planners, drafters, architects, and engineers, the medium to be erased, revised, smudged, obliterated, lost—or inked over. Ink, on the other hand, whether in a book or on plans or on a contract, signifies finality and supersedes the pencil drafts and sketches. If early pencilings interest collectors, it is often because of their association with the permanent success written or drawn in ink. Unlike graphite, to which paper is like sandpaper, ink flows smoothly and fills in the nooks and crannies of creation. Ink is the cosmetic that ideas will wear when they go out in public. Graphite is their dirty truth.

A glance at the index to any book of familiar quotations will corroborate the fact that there are scores of quotations extolling the pen for every one, if that, mentioning the pencil. Yet, while the conventional wisdom may be that the pen is mightier

than the sword, the pencil has come to be the weapon of choice of those wishing to make better pens as well as better swords. It is often said that "everything begins with a pencil," and indeed it is the preferred medium of designers. In one recent study of the nature of the design process, engineers balked when they were asked to record their thought processes with a pen. While the directors of the study did not want the subjects to be able to erase their false starts or alter their records of creativity, the engineers did not feel comfortable or natural without a pencil in their hands when asked to comment on designing a new bridge or a better mousetrap.

Leonardo da Vinci seems to have wished to make a better everything, as his notebooks demonstrate. And when he wanted to set down his ideas for some new device, or when he merely wanted to record the state of the art of Renaissance engineering, he employed a drawing. Leonardo also used drawings to preserve his observations of natural facts, artifacts, and assorted phenomena, and he even sketched his own hand sketching. This sketch is usually identified as Leonardo's left hand, consistent with the widely held belief that the genius was left-handed. This trait in turn has been given as a reason for his mirror writing. However, it has also been convincingly argued that Leonardo was basically right-handed and was forced to use his left hand because his right was crippled in an accident. Thus Leonardo's sketch may really be of his maimed right hand as seen in a mirror by the artist drawing with his fully functioning left hand. The shortened and twisted middle finger in the sketch supports this view.

The precise nature of the drawing instrument in Leonardo's hand may also be open to some interpretation, but it appears most likely to be a small brush known from Roman times as a pencil. The lead pencil as we know it today does not seem to have existed in Leonardo's lifetime (1452–1519). Some of his sketches were done in metal point, but drawing with a pointed rod of silver or some alloy usually had to done on specially coated paper so that an otherwise faint mark would be enhanced. Some drawings were first outlined in metalpoint and then more or less traced over with a pen or a fine-pointed brush dipped in ink. This was the only kind of pencil Leonardo knew.

Nevertheless, even in their complex medium, Leonardo's notebooks were almost lost to posterity. Their author never published their contents, and after he died the thirty-odd volumes almost passed into oblivion. He left them all to his friend

Leonardo da Vinci's sketch of his own hand sketching, either his left hand or his right seen in a mirror

and pupil Francesco Melzi, with an injunction: "In order that this advantage which I am giving to men shall not be lost, I am setting out a way of proper printing and I beg you, my successors, not to allow avarice to induce you to leave the printing un . . ." But the sentence seems never to have been finished, and the proper printing took longer than Leonardo must have hoped. Melzi kept the notebooks locked away for fifty years, so, except for a treatise on painting, which was extracted for publication in 1551, the bulk of Leonardo's engineering remained private, and by the time the notebooks were published in 1880, virtually all of the inventions were either rediscovered or superseded.

Engineers throughout history have tended to work out their plans in less permanent media and have suffered the obscurity that Leonardo escaped only through the sheer mechanical and artistic brilliance of his notebooks. Because they are the subjects of manuscripts and books, we know much more about the wrongheaded theories of the universe and the unrealistic utopias of dreamers than we do about the ingenious and successful engineering achievements of the ages. And this is due at least in part to the fact that, long before the time of Leonardo, drawing rather than writing was the medium of thinking and planning for the engineer. But plans and drawings were not the subject of scholarship. Lynn White, Jr., was especially aware of the need to look beyond the written record. In the preface to his brilliant study of the role of artifacts such as the stirrup in the story of civilization, he wrote:

> If historians are to attempt to write the history of mankind, and not simply the history of mankind as it was viewed by the small and specialized segments of our race which have had the habit of scribbling, they must take a fresh view of the records, ask new questions of them, and use all the resources of archaeology, iconography, and etymology to find answers when no answers can be discovered in contemporary writings.

The transient practice of engineering has been by and large an invisible and unrecorded aspect of the history of civilization. While we do have artifacts from all ages that we recognize as tools, structures, or machines, we tend to see them as discrete pieces of material detritus in the context of cultural development. It is less easy to deal with the origins of those artifacts as deliberate acts of invention and the evolution or "perfection" of them as deliberate acts of engineering, especially since such interpretations depend ultimately upon presumptions about the thought processes of our distant ancestors. Did they really practice engineering or did they just stumble upon happy accidents of nature in the form of fortuitously shaped rocks and fallen trees bridging streams? Have we always been victims of circumstance or have we from the start been conscious inventors and conscious engineers?

Marcus Vitruvius Pollio, whose *De Architectura* in ten books is the main source for the history of engineering in ancient Rome, argues that our ingenuity is innate. But Vitruvius did not believe that the advancement of civilization could rest on innate qualities alone, and he listed skill with the pencil —the fine-pointed brush that Leonardo used—only behind education as one of the prerequisites for the architect, or engineer, of two millennia ago. Drawing was essential.

What the earliest engineers do not seem to have done, of course, is to have *written down* much, if anything, about their work. Vitruvius' twenty-centuries-old classic is generally considered to be the oldest surviving work on engineering, but it is also about the aesthetics of building, and it seems to have

survived for that reason alone. One historian said of Vitruvius what many have implied: "He writes in atrocious Latin, but he knows his business." And a classicist said, "He has all the marks of one unused to composition, to whom writing is a painful task." But whether he deluded himself about his own writing ability or simply did not think skill with the pen to be as important as that with the pencil, beginning with Vitruvius and continuing to this day, writing about engineering has been generally less than poetry and often dominated by a labored description of artifacts, a prosaic prescription of rules for emulating those artifacts, and an overwhelming concentration on the technical "business" of making artifacts. There is a paucity of any kind of literature, either well articulated or written in forgettable and forgotten prose, on how the earliest engineers used "their natural gifts sharpened by emulation" to come up with the ideas for new and improved artifacts in the first place.

But whether it is recorded or not, the process of engineering, what is commonly referred to as the engineering method, is actually much older than Vitruvius—indeed, as old as civilization itself—and it has come down to us today essentially unchanged in its most basic characteristics. While engineering as a formal and distinct profession may be only a century or two old, engineering as a human activity has been, and is, virtually changeless and timeless.

Vitruvius propagated the myth that engineering is applied science. Yet there is an astonishing imagination in engineering, an imagination independent of science, but it has been realized in pictures and artifacts and not in words. And as the pictures are erased as the artifacts themselves remove the need for pictures, so the artifacts wear out because they are designed not as objets d'art but as things to be used, indeed things to be consumed in their very use. While every artifact embodies the methods of technology, the pencil is an especially appropriate one to study. Not only can the pencil serve as a symbol of engineering itself; the development of this artifact of remarkable ingenuity, complexity, and universality may also serve as a paradigm for the engineering process generally.

As there have always been engineers, so there have also always been philosophers. The artifacts of philosophers are, of course, their writings, and the survival of writings about matters philosophical has too often led to the facile conclusion that matters practical were somehow of lesser importance. This is not necessarily so, but as late as the Renaissance, it was

still largely the case that "the social antithesis of mechanical and liberal arts, of hands and tongue, influenced all intellectual and professional activity," and well into modern times the artisans and craftsmen who helped advance the technology, albeit slowly, of everything from writing implements to ships were not educated and "probably often illiterate." And if even Leonardo's notebooks could remain unread for so many centuries, what expectation could there be that humanists would "read" the poetry and history embodied in artifacts? With the rise of what have been called "artist-engineers" like Leonardo, technological subjects came more and more to be recorded, but for the most part only in notebooks and manuscripts that circulated among other artist-engineers.

The business and technology of making pencils have obscure roots and have evolved in fits and starts out of the unwritten traditions of craftsmanship. The reasons for many of the physical characteristics of the pencil are as lost in those traditions as are the origins of the sizes and shapes of many a common object, but the relatively recent origin and short history of the modern pencil also makes it a manageable artifact to twirl about in the fingers and reflect upon in the mind. When we do this we also realize that for all its commonness and apparent cheapness, the pencil is a product of immense complexity and sophistication. Thus there is much to be learned from the pencil and the story of its development for illuminating the nature of engineering and engineers and, by extension, modern industry. Problems faced over the centuries by pencil makers and manufacturers are not without their lessons for today's international technological marketplace. Used like the Socratic method, the pencil can draw out of us realizations about things of which we might never have thought.

In the late twentieth century, when there are billions produced each year and sold for pennies, it is easy to forget how marvelous and dear an object the pencil once was. According to the prayer of an old Nubian, recorded in an 1822 journal of a visit to Ethiopia: "Praised be God, the Creator of the World, who has taught men to inclose ink in the centre of a bit of wood." A century later and an ocean away, the pencil could still evoke wonder, but the manufacture of the artifact was seen to involve a lot more than just "ink in the centre of a bit of wood." In order to manufacture a pencil, according to the early-twentieth-century account of a participant in the process:

the writer has had to become familiar with the nature of hundreds of dyestuffs, of shellac and many other resins, of clays of all kinds and from all parts of the world, of the many varieties and qualities of graphites, or many kinds of alcohols and other solvents, of hundreds of natural and artificial paint pigments, many varieties of woods, and general knowledge of the rubber industry, of the glue industry and of printing inks, of nearly all varieties of waxes, of the lacquer or soluble cotton industry, of many types of drying equipment, of impregnating processes, of high temperature furnaces, of abrasives and many phases of extrusion and mixing processes.

Looking at my career in the pencil industry, along a perspective of some eighteen years, I am dumbfounded at the many angles it takes, at its polyphase ramifications, at the difficulties in developing a trained staff of assistants, at the extreme accuracy required of the tools, and at the broad knowledge of practical chemistry necessary, as well as the expert knowledge of the proper sources of supplies of raw materials, required to get anywhere with pencil manufacture, so as to compete in the markets of the world.

This is an excellent summary of the many facets of engineering involved in making a modern pencil. "Practical chemistry" is, of course, today called chemical engineering, and knowledge of the various specialties of mechanical engineering, materials engineering, structural engineering, and even electrical engineering is invaluable for manufacturing attractive pencils that can be sharpened to fine points that are strong and will write smoothly. And the fruits of all this expert knowledge are made available for a fraction of what it would cost merely to assemble the materials. While one oft-repeated definition of an engineer is someone who does for one dollar what anyone can do for two, in the case of a mass-produced pencil, the economic advantage is even more pronounced. In the 1950s, it was estimated that a "do-it-yourself addict" would have to spend about fifty dollars to make a single pencil.

While the Smithsonian Institution neglected to include pencils on the worktables of late-eighteenth-century craftsmen, in an earlier show, "A Nation Among Nations," it acknowledged that "all the principles of mass production can be seen at work in the manufacture of the common wood-cased pencil," and a pencil-making machine built in Tennessee in 1975 was displayed. Now, in the Smithsonian's most recently installed permanent exhibition, "A Material World," which serves as "an introduction to the entire National Museum of American History," there is a display showing how "stuff" is transformed into "things," and the raw materials of a pencil serve as the paradigm. These are fitting acknowledgments of the importance of the pencil and other engineered artifacts in influencing and being influenced by our more general culture. However, there remains a strong intellectual tradition that generally ignores the fact that the art and literature we cherish would be of quite a different nature without such technological artifacts as pencils.

In the Concord, Massachusetts, Free Public Library there are shelves of editions of Thoreau's *Walden* and shelves of books on the author's times, writings, and thoughts. One catalogue of these Thoreau Society archives lists more than one thousand items, but the number of those dealing specifically with Thoreau as pencil maker and engineer of pencil-making machinery is nil. While a "nail picked up at the Thoreau cabin site" is included among the literary works, no pencil is. Only a Thoreau & Company pencil label (printed in ink, of course) gives any hint of the activity that provided the family income. One must learn of Thoreau the pencil engineer almost by inference from the few scanty references within more general works that the curator happens to recall. There are now a few pencils among the books and literary material in the Thoreau alcove in the library, but their method of manufacture seems to be more mysterious than that of any of Henry David Thoreau's literary works.

While it may be excusable that Thoreau's pencil engineering is seldom emphasized relative to his other achievements, there is no excuse for ignoring engineering in our culture generally. Yet it is rare to find generalizations about engineering qua engineering that are the equivalent of the scientific method or to find universal insights about engineering that have the ring of Archimedes' "Eureka!" Great engineers have seldom left articulate generalizations or insights in ink; they have usually only sketched them in pencil, to be fleshed out in state-of-the-art structures and machines. Yet even as the state of the art is constantly evolving and developing, there are deep underlying similarities in what the first engineers or those described by Vitruvius did and what today's engineers still do. And it is the timeless features of the creative process sometimes called the engineering method, with the curious attributes that make it

possible for essentially the same method to coexist in both naïve and sophisticated minds, that are innate in all of us. These features are also the reason why engineering always has been and always will be more than mere applications of mathematical theorems and physical principles. It is high time to write in ink for publication what engineers have for so long only sketched in pencil in their notebooks. The history of the pencil itself provides an excellent opportunity to learn more about engineering.

2/ Of Names, Materials, and Things

What has come to be known as a pencil was named that because it resembled the brush known in Latin as a *penicillum*. This fine-pointed instrument, which was formed by inserting a carefully shaped tuft of animal hairs into a hollow reed, much as a piece of lead is inserted into a mechanical pencil today, in turn got its name as a diminutive form of the more general Latin term for brush, *peniculus,* itself a diminutive form of the word *penis,* which is Latin for tail. This word was used for the very first fine brushes because they were actually formed from the tails of animals. Thus a pencil is literally a "little tail," which can be used for writing or drawing fine lines.

A Roman *penicillum,* or pencil brush

While it might be possible to give all sorts of anachronistic, prurient, and sexist interpretations for the etymology of the word "pencil," our interests are better served by looking at the functional rather than the Freudian antecedents of the object. The name of an artifact may certainly depend upon symbolic and subliminal evocations, but artifacts themselves do not come from their names. Indeed, the modern pencil is called what it is because it, like all technological objects, is more likely than not the product of distinctly nonverbal thinking.