TECHNOLOGY, VALUES, AND ETHICS: A FRAMEWORK
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Three words of my title--"technology", "values", and "ethics"--have this in common: they have all been used in enough different ways to be dangerous. To provide the framework my title promises, I shall have to distinguish the most important of those uses, set them in context, and explain how they are (or are not) related. This conceptual house-cleaning, rather boring in itself, will give me the opportunity to talk about engineering, both its history and practice. That will not be boring.[1]

I.   *Techne* and *Sophia*: Twins Ancient but Unequal

"Technology" is a compound of two words from ancient Greek, "techne" and "logos". "Techne" means manual art. So, for example, a "tekton" was a carpenter or builder; an "architect", a master builder. The suffix form of "logos", "-ology", means a putting into words, an explanation or study. So, when our word "technology" still meant what Greek tells us it means, technology was the explanation or study of manual art, just as biology is the explanation or study of *bios*, life. It was a field in which gentlemen entered the workshop to record the artisan's secrets for later publication.[2]

That, of course, is not what "technology" means now. Despite its Greek root, "technology" is really a new word, recoined in the middle of the last century for a new idea. What idea?

Ancient Greece was a slave-owning society and, like other slave-owners, Greeks tended to associate manual labor with slaves. Since no free man would want to be mistaken for a slave, the ancient Greeks generally avoided doing what slaves do. For example, because slaves tended to rush about on their master's business, free men were

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[1] **I should like to thanks Wilbur Applebaum for helpful advice on my first draft.**

[2] **See, especially,** Paolo Rossi, Philosophy Technology, and the Arts in the Early Modern Era, trans. S Attanasio (Harper and Row: New York, 1970. Interestingly, the Oxford English Dictionary gives the first known use of the word "technology" in English is as 1615.

supposed to walk slowly.[3] Greeks had such a low opinion of manual labor that they even rated sculpture less noble than painting because the sculptor, unlike the painter, had to sweat over his work like a slave.[4]

There were few exceptions to this low opinion of manual labor. One was athletics. Athletics, however sweaty, was not something slaves did. War was another exception. Hacking one another with swords, though hard and dirty work, was a job for free men.

The Greeks contrasted *techne* with *sophia*. Though often translated as "intellectual knowledge" or even "science", "sophia" is probably better translated as "wisdom". From "sophia" comes our word "philosophy" (the love, that is, the pursuit of wisdom). For the Greeks, philosophy included mathematics, physics, economics, and similar sciences. Because philosophy was primarily a matter of thought, not manual art, philosophy was appropriate to free men.

The Greeks of Greece's Golden Age loved sophia; and she rewarded them accordingly. The Greeks of that period can claim credit for beginning the tradition of philosophy now dominant over most of the world, the one to which I belong. They can also claim credit for beginning a number of the sciences, including geometry, biology, and political science.

Their achievements in poetry, architecture, and history are no less impressive. Not so their contributions to *techne*. Of course, there were some contributions, for example, improved design of war galleys. But you must hunt for them. Europe's Dark Ages seem to have given us many more useful devices than did Greece's Golden Age."[5]

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[3] See, for example, Plato's Theaetetus (III: 172-173): "[A] philosopher is a gentleman, but a lawyer is a servant. The one can have his talk out, and wander at will from one subject to another, as the fancy takes him... [but] the lawyer is always in a hurry..."

[4] Hannah Arendt, The Human Condition (Doubleday: Garden City, New York, 1959), p. 323n.

[5] . "If we assume that the Middle Ages ended with the fifteenth century then a simple count of inventions made or adopted by Europeans during the period confirms that it was, as regards technics, more creative than any previous epoch in recorded history." Dictionary of the History of Ideas: Studies of Selected Pivotal Ideas, edited by Philip P. Weiner (Charles Scribner's Sons, Publisher: New York, 1973), vol. IV, p. 359 (D.S.L. Cardwell, "Technology"). I am, of course, still comparing Greece's Golden Age with a similar stretch of time during the Dark Ages. Were I to compare the Dark Ages with the Hellenistic Period, I might have to edge my claim in a number of ways.

By now, perhaps, you can see two reasons to distrust that ugly word, "technology":

First, there is the implicit opposition between *sophia* and *techne*. Today we think of science and technology as related, not opposed. So, for example, one reason politicians give for funding scientific research is that it will pay off in new technologies.[6]

Second, there is the word's meaning in Greek. For us, technology is not--as its Greek parts suggest--a study of manual art but, primarily, our way of referring to all those inventions that make manual labor easier, more productive, or unnecessary. In this sense, technology began with the first tool someone made; the new technologies we hear about are new technologies in this sense, new tools someone has made.

Of course, there is yet another sense of "technology", one derived from this but referring to a study--as in, for example, the title "institute of technology" (or "technological university"). An institute of technology is not, as the Greek suggests, a place to study manual arts (carpentry, machining, and so on), a mere technical school. An institute of technology is, instead, a place to study practical inventions, how to make them and how to use them to make other useful things. The Greeks, who had a word for almost everything, seem not to have had a word for that.

 So what? What does this history have to do with us? Consider, for example, how we dress for work: Some of us dress in "white collars", that is, fine shirts, ties, good slacks, dresses, sport coats, or the like. Others wear "blue collars", that is, coarse shirts, denim pants, coveralls. Generally, those in white collars have higher status than those in blue. Salary is secondary (as is social usefulness). A carpenter has less status than an accountant earning half as much. Why? Though carpentry requires a trained mind, it requires as well, like other blue-collar work, much sweaty labor surrounded by dust and debris. Because such labor would quickly ruin good clothing, the white collar guarantees some distance between its wearer and such "slavish labor". And, because it does that, the white collar confers status.

No matter the origin of our parents, we are, in this respect at least, all more or less descendants of the ancient Greeks. Even if we ourselves like manual labor, we do not

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[6] See, for example, Spencer Klaw, "The Faustian Bargain", in The Social Responsibility of the Scientist, edited by Martin Brown (Free Press: New York, 1971), pp. 3-18.

respect it as much as mental labor. I doubt that this is good, especially for engineers. But it does seem to be a stubborn fact about us. We are prejudiced against blue collars, not only those who work in them but even those who associate with those who work in them.

That prejudice shows up even in a phrase seemingly having nothing to do with it—"science <u>and</u> technology". Why does "technology" always come second? The explanation cannot be historical. If "technology" refers to inventions making manual labor easier, technology is older than science by thousands of years. And, even if "technology" in that expression refers instead to the <u>systematic</u> study of practical invention, technology would be no younger than science in the corresponding sense, the systematic study of nature. For, until quite recently, "science" meant all systematic knowledge, whether of nature or invention, including even jurisprudence and theology.

Nor can the explanation of the inevitable priority of "science" be alphabetical order. Substitute "engineering" for "technology" and the order remains the same: "science and engineering", <u>not</u> "engineering and science". Nor can the explanation be practical importance. Technology bakes our bread; science only helps us to understand how. Nor can the explanation be mere accident. Accident would produce more variation. The order seems fixed: science <u>and</u> technology. Why?

The answer, I think, is that the order indicates relative status. Science has higher status than technology; hence, it gets first mention.

Well, shouldn't science have higher status? After all, isn't technology just applied science? Doesn't science come first in the order of development? Doesn't science lay down the law, like a master, while technology merely applies it, like a slave? Even engineers may be tempted to answer yes to these questions. But the answer is: No, technology is <u>not</u> merely applied science.

II.   Science, Technology, and Engineering

One can understand the words "science" and "technology" so that they refer to comparable concepts. Science is explicit, systematic knowledge of how "nature" works; technology, explicit, systematic knowledge of how to make useful things. Unfortunately, usage today is not so neat. Though the term "science" did once refer (primarily) to

explicit, systematic knowledge of nature, its meaning has now shifted somewhat so that, today, it refers as much, or instead, to a social undertaking, "a voyage of discovery" (as scientists like to say), rather than merely to what they discover. In this sense, science consists of certain communities engaged in trying to understand how nature works.

Since "technology" refers to our practical inventions, or to the study of how to make more, we lack a term comparable to this new sense of "science". What do we call communities that invent useful things or, at least, add to our knowledge of how to do it? "Technician" is wrong: a technician is an assistant, one who carries out routine work under direction of a scientist, engineer, architect, physician, or the like. "Technologist", though a natural choice, has not caught on; "applied scientist", though once popular with sociologists, natural scientists, and even some engineers, is now fading.

Why? I think the reason is that the great majority of people who would have to be called "technologist" or "applied scientist" already have a satisfactory name, "engineer".

I said "great majority". I meant it. The United States today has well over 2,000,000 engineers. That is more than all other "technologists" together. Most other "technologists" are either architects, chemists, physicists, biologists, physicians, computer scientists, or mere inventors. There are in the US only about 135,000 architects, 388,000 natural scientists (including chemists, physicists, and biologists), 450,000 computer scientists, and 600,000 physicians.[7] I have no figure for "mere inventors"; but, since most inventors seem to be engineers, there can't be many "mere inventors". The number of physicians contributing technology also cannot be large. Most physicians are not in research or development, but simply provide health care. So, even assuming that most scientists are in technology, not pure research, engineers must outnumber all other technologists combined by about two to one.

These numbers suggest an obvious solution to the problem of what to call all those who make technology: call them "engineers". But that would, I think, be a terrible mistake. Chemists, architects, physicians, biologists, computer scientists, and the like are not engineers. Understanding why they are not will help us to understand both the values inherent in most technology, the technology engineers develop, and the place of ethics in

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[7] World Almanac (World Almanac: New York, 1989), p. 158.

any technology. It will also bring us to the heart of our subject. But it will require more history, though (mostly) history less ancient than before.

III. The Beginnings of Engineering

Some histories of engineering begin with the Stone Age, with the first tools. They confuse engineering with technology.[8] Other histories begin more sensibly, with the recognition that engineers generally do not do manual labor but prepare instructions for others to carry out. Since the first tool almost certainly pre-dates such a division of labor, these histories begin much later, with the first projects large enough to have some people laying out a plan and others implementing it. They begin with the building of Stonehenge, the Pyramids, or some other wonder of ancient civilization.[9]

Though better than the first, this second way of beginning the history of engineering still has at least two embarrassing consequences. One embarrassment is that it makes architects the first engineers. This is embarrassing because engineers generally agree that architects today are definitely not engineers. Another embarrassment is that this way of telling the story makes a mystery of why our word for engineer comes from French, rather than Greek, like "architect", and why the French have had the word for barely four hundred years. Generally, we have a word for anything important to us almost as soon as we have the thing. There are no significant whatchemacallits.

So, when I tell the story of engineering, I start four hundred years ago in France. Back then there were things called "engines"—but "engine" then simply meant a complex device for some useful purpose, a contraption showing intelligence in design, in short, a machine. The first people to be called "engineers" were soldiers associated with catapults, siege towers, artillery, and other "engines of war". They were not yet engineers in the

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[8] See, for example, M. David Burghardt, Introduction to the Engineering Profession (HarperCollins Publishers: New York, 1991), p. 26: "We shall assume that wherever there was an invention or innovation, engineering was required."

[9] See, for example, Ralph J. Smith, Engineering as a Career, 3rd (McGraw-Hill: New York, 1969), p. 22: "It has been said that the history of civilization is the history of engineering. Certainly it is true that the highly developed civilizations have all been noted for their accomplishments in engineering." Substitute "building" for "engineering" and there would be nothing to object to.

sense that concerns us. They were, rather, engineers in the sense that, even today, the driver of a locomotive is an engineer. They were engineers only in the sense that they operated (or otherwise worked with) engines.

Some soldiers are still engineers in something like this sense: they belong to an engineering corps. Though they do not know what engineers know, they are directly involved in works of engineering, though not precisely with engines of war, a term no longer in common use.

Four hundred years ago the armies of France were led by nobles, men on horse back, who learned war from their fathers, or on the battlefield, or died in the attempt. The foot soldiers came with the nobles. Most were peasants or artisans who knew little of war until trained in camp. When the war ended, the army dissolved, each noble leading his own people home. In such an army, an "engineer" was usually a carpenter, stone mason, or other artisan bringing civilian skills to war.

When Louis XIV ended the regency in 1661, France still made war in this way. But, within two decades, France had a standing army of 300,000, the largest, best trained, and best equipped European fighting force since the Roman legions. This achievement was widely copied. To this day, most of our military words--from "army" itself to "reveille", from "bayonet" to "maneuver", from "private" to "general"--are French. "Engineer" is just one of these military terms.

Until 1676, French engineers were part of the infantry. But, in that year, the "engineers" were organized into special units, the *corps du genie*. This had important consequences. A permanent corps can keep much better records than isolated individuals, can accumulate knowledge, skills, and routines more efficiently, and can pass these on. A corps can become a distinct institution with its own style and reputation. More than a group of proto-engineers, the *corps du genie* was, potentially, both a center of research in engineering and a training ground for engineers.

The *corps du genie* did not take long to realize this potential. Within two decades, the corps was known all over Europe for its unusual achievements in military construction. When another country borrowed the French word "engineer" for use in its

own army, it was for the sort of activity the *core du genie* engaged in.[10] That was something for which other European languages lacked a word.

The *corps du genie* was not, as of 1700, a school of engineering in our sense; it was more like an organization of masters and apprentices. Indeed, strange as this may seem now, at that time neither France nor any other European state had a permanent military academy of any sort, much less a school of engineering. There was no settled curriculum for training officers generally or engineers in particular, or even a very clear idea that that was necessary. Only during the 1700s did the French slowly come to understand what they wanted from an engineering education and how to get it. But, by the end of the 1700s, they had a curriculum from which today's engineering curriculum differs only in detail; they had also invented engineering.

An army needs fortifications for protection, mines under enemy fortifications, roads to march on, and bridges to cross. Civilians either need the same things or other things requiring similar skills to build. So, in 1716, the French established a second corps of engineers, the *corps des ponts et chaussees*, to build and maintain the nation's bridges, roads, and canals. This corps set up a school for training its officers, the first engineering school to survive long enough to matter. Its graduates were soon called "civil engineers" to distinguish them from the (purely) military engineers of the *corps du genie*. Like the military engineers, the civil engineers were admired all over Europe. Those who copied their method copied their name as well.[11]

What was their method? Engineers, military as well as civil, resembled architects in being able to make drawings for construction projects, develop detailed instructions from those drawings, and oversee the execution of those instructions. They nonetheless seem to have differed from architects in at least three ways.

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[10] See, Frederick B. Artz, The Development of Technical Education in France, 1500-1850 (MIT Press: Cambridge, Massachusetts, 1966), p. 48; or W. H. G. Armytage's (misnamed) history of engineering in Britain, A Social History of Engineering (Faber and Faber: London, 1961), pp. 96 and 99.

[11] Artz, 47-48.

First, engineers were much better trained in (what was then) the new mathematics and physics than the architects. They had the ability to consider systematically questions most architects could only deal with intuitively or ignore.[12]

Second, because the strategies of engineering had their roots in the necessities of war, engineers paid more attention to reliability, speed, and other practicalities. So, for example, the systematic testing of materials and procedures in advance of construction was early recognized as a characteristic of engineers.[13] At least in comparison, the architect seemed an artist, one for whom beauty claimed much of the attention an engineer would devote to making things work.

Third, to be an engineer was to have been trained as an army officer, to have been disciplined to bear significant responsibility within one of world's largest organizations. Engineers were therefore likely to be better at directing large civilian projects than architects, most of whom would have had experience only of much smaller undertakings.

These three advantages tend to reinforce one another. For example, large projects not only require more planning in advance and more discipline in execution, they are also more likely to require better mathematical analysis and to justify extensive testing of materials and procedures. For this, and perhaps other reasons, civil engineers slowly took over much of the work that once would have been the domain of architects. They were a new power in the world.

Early experiments in engineering education culminated in the *École Polytechnique*. Begun in 1794 as the *École des Travaux* (the school of public works), it changed its name the following year, for the first time connecting engineering and "techne". I don't know why the French did this. The school never trained architects, much less artisans or mechanics. It was always a school of engineering, deserving the "poly" only for offering preparation for many fields of engineering, military and naval engineering as well as civil.

The *École Polytechnique*'s curriculum had a common core of three years. The first year's courses were geometry, trigonometry, physics, and the fundamentals of chemistry with practical applications in structural and mechanical engineering. There was a good

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[12] Engineers also had some secret methods (for example, Monge's descriptive geometry). Artz, 106.

[13] Artz, 81-86.

deal of drawing, some laboratory and workshop, and recitations after each lecture. The second and third year continued the same subjects, with increasingly more application to the building of roads, canals, and fortifications and the making of munitions. For their last year, students were sent to one of the special schools: the school of artillery, the school of military engineering, the school of mines, the school of bridges and roads, the school of geographical engineers, or the school of ships.[14]

Engineers will immediately recognize this curriculum, both the four years and the progression from theory (or analysis) to application (or design).

The *École Polytechnique* became the model for engineering education for much of the nineteenth century.[15] Its first impact in the United States occurred surprisingly early. Our first engineering school was the Military Academy at West Point. In 1817, it adopted much of the *École*'s curriculum, its methods of instruction, and even a text.[16]

III.   Values in Engineering

What values does engineering incorporate? A decade ago, James Ferguson, an engineer turned historian, drew up a list of what he called "imperatives of engineering".[17] The list is neither complete nor fundamental. It will nevertheless help us understand engineering.

Engineers, Ferguson claimed, (1) strive for efficiency, (2) design labor-saving systems, (3) design control into the system, (4) favor the very large, the very powerful, or (in electronics) the very small, and (5) tend to treat engineering as an end in itself rather than as a means to satisfying human need. These "imperatives" are, according to Ferguson, instincts engineers bring to their work. While an engineer can resist them, just as I can resist drinking water even if I am thirsty, they are, in effect, the engineer's default setting, what engineers will do unless they consciously try to do something else.

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[14] Artz, 154-155.

[15] Artz, 160.

[16] Artz, 160-161.

[17] James Ferguson, "The Imperatives of Engineering", from John G. Burke et al., Connections: Technology and Change (---- and Fraser: San Francisco, 1979), 30-31.

Ferguson intended this list to be a criticism of the way engineers work. It is, I think, both less and more than that. The list is less than a criticism because at least the first four imperatives seem, on reflection, at least as much virtues as vices. The list is also more than a criticism because it highlights certain enduring features of engineering, permitting us to connect engineering's history with today's practice. Let's take a closer look at Ferguson's list.

"Efficiency" is the first imperative Ferguson identifies. Ferguson points out, rightly, that "efficiency" is a slippery term, meaning "most powerful" here, "lowest cost" there, and something else elsewhere. What he overlooks is the concept's utility.

Engineers always define "efficiency" so that they can measure it (or its components), assign numbers, and thereafter seek to control it. That is not surprising. Like other professions, engineering tends to analyze a situation so that its distinctive skills can be applied. One distinctive skill of engineers is giving mathematical structure to practical problems. The concept of efficiency allows them to exercise that skill.

Engineers have, no doubt, often paid too much attention to efficiency, especially forms of efficiency that turned out not to matter. Indeed, the history of engineering is in part the history of measurable properties used for a time as proxy for something that could not be measured and then discarded when the proxy proved not to have enough of a relation to what the engineers actually cared about.[18]

Because engineering is a practical undertaking, it must learn from practice. It cannot learn from practice without making mistakes. Some of engineering's mistakes have concerned efficiency. Engineers can, of course, be unduly slow about giving up one of these proxy measures. But, even this slowness is understandable. Engineers are used to working in large organizations, organization where change is difficult and the consequences are often hard to predict. They therefore have a tendency to cling to practices they would no longer adopt. The world is a tough laboratory. Many things better in theory are worse in practice. How daring do we want engineers to be with our lives?

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[18] For a detailed study of one of these proxy measures that, in the end, had to be discarded, see Walter G. Vincenti's discussion of "stability", in What Engineers Know and How They Know It (Johns Hopkins University Press: Baltimore, 1990), pp.51-108.

The second imperative on Ferguson's list is a preference for labor-saving devices. Engineers will, Ferguson thinks, design to save labor even when labor is cheap and the end result will be higher production costs and more unemployment.

The engineer's preference for labor-saving is understandable as a product of engineering's military origin. Since engineering began, the primary labor pool of most armies has been their own soldiers. Since no general wants his soldiers doing construction when they could be fighting, military engineers have always had an incentive to look for means of saving labor even though the labor saved was, in one sense, cheap (indeed, free).

As military engineering became civil engineering, this tendency might have put engineers at a disadvantage. Their designs might have proved too costly. Those who hired engineers would, however, soon have learned this. They would then have compensated, either by being careful about when they called an engineer in or by making sure that the engineer defined the desired outcome taking cost into account.

If, as Ferguson's criticism suggests, such compensation seldom occurs, the most likely reason is that the engineer's preference for labor-saving devices generally serves those who employ engineers. The reason that preference might serve their employers is not hard to see. Labor has a tendency to become scarce, and so costly, where it is not routinely saved.

Of course, that is only a tendency. Many of those thrown out of work by a particular innovation live out their lives on the dole. Many engineers would, no doubt, like to take such effects into account; and perhaps many of their employers would let them. But, if engineers are to take such considerations into account, they will need both the relevant information and a routine for using it.

Gathering such information belongs to the social sciences, not to engineering as it is or as it is likely to become. Any curriculum that could give engineers the skills to develop significant social statistics would probably be too long to attract many students. Engineers should not be blamed for failing to take into account social consequences about which they can only guess.

Where, however, such information exists, developing ways to incorporate it into engineering work is certainly something engineers can, and should, do. Indeed, they have

long done this with the employer's share of the cost of production. And, over the last two decades, thanks to the Environmental Protection Agency (EPA), engineers have become adept at incorporating environmental costs into their designs. They could do the same for social impact if they had numerical standards for assessing impact and sources of information from which the relevant numbers could be taken.

Engineers can help to develop such standards, just as they helped to write EPA standards. But, just as with environmental standards, standards for permissible social impact are probably not what most people would want engineers alone to decide--or even engineers with the help of lawyers, accountants, corporate executives, and other specialists. Social impact raises political issues, that is, issues everyone wants a part in deciding. If engineers decline to develop such standards unilaterally, should we blame them?

Ferguson's third imperative is designing controls into the system. Engineers generally try to separate planning and execution. Intelligence is designed into the system, requiring as little intelligence as possible of the system's operators. The assembly line is the typical example of this imperative. Engineers have generally tried to design an assembly line so that the work is so simple that only a few minutes training is necessary to learn the job. The job is therefore likely to be repetitive and boring.

Engineering's military past certainly explains the origin of this imperative. Soldiers sent over to help on an engineering project, whether digging trenches or putting a bridge over a river, will not have much time to learn the job. The military engineer must design the work so that anybody can do it.

But its military past alone does not explain why this imperative persists in civilian engineering (or, at least, why engineers who do such things should be so much in demand). The explanation of that, like the persistence of engineering's second imperative, must be that this tendency has proved useful in civilian engineering as well. One recent example will suggest why that might be.

McDonald's restaurants now have cash-register buttons with pictures of the various items on the menu. The cashier need not know the price of anything, or even be able to read, only be able to recognize the pictures and push buttons accordingly. In a business where employee turnover is high and education low, where prices change

frequently and training is expensive, this dumbing-down of the job both saves money for McDonald and opens employment to many who might not otherwise be qualified. Whoever thought of that device, engineer or not, was undoubtedly a hero to McDonald's.

The fourth imperative of engineering Ferguson lists is a tendency to disregard human scale, preferring the very large or the very small. The reason for this imperative is that engineering was, and remains, a creature of large organizations. Louis XIV's army, one of the largest organizations of its day, created engineering to do what civilian artisans could not do. Even today, most engineers work in large organizations. You do not need an engineer to construct a single family house. A carpenter or architect will do, as they always have. If, however, you want to construct a thirty-story building, you will need engineers.

The problem, I think, is not so much that engineers disregard human scale as that they are seldom needed for things on a human scale. Generally, asking engineers to work on a human scale is like asking lawyers to prepare a partnership agreement for two children opening a lemonade stand. They can do it, but either they will do what anyone else could do or they will do something out of all proportion to the job.

In this respect, the very small can be like the very large. For example, to make today's tiny electronic circuits requires productive forces of which a single human being is incapable. Hence, there is work for engineers.

Ferguson's last imperative, putting technical brilliance ahead of human need, is unlike the others. It is a failing common to all professions.--We all know the joke about the surgeon who says, "Though the patient died, the operation was a success."--But this last "imperative of engineering" is worse than a failing common to all professions; it is a failing inconsistent with one of engineering's fundamental values.

I have stressed the military origins of engineering. I have not pointed out that most of the period we have been talking about, roughly the 1700s, is known as the *Age of Enlightenment*. This was the time many Europeans first came to believe that enlightenment, that is, scientific education, would bring peace, prosperity, and continuous improvement.

For countless ages, the best hope of the wise was that the world would not get much worse. With the Age of Enlightenment, people began to act on the belief that the world could be made much better. Engineering has this belief built into it.

For example, early graduates of the *École Polytechnique* were noted for "scientific and democratic idealism and a desire to work for human progress".[19] The same attitude was evident in England at about the same time. When, in 1828, the British Institution of Civil Engineers, then nine years old, asked one of its members, Thomas Tredgold, to define the term "civil engineering", he gave an answer engineers still quote: "Civil Engineering is the art of directing the great sources of power in Nature for the use and convenience of man...The most important object of Civil Engineering is to improve the means of production and of traffic in states, both for external and internal trade."

For Tredgold, engineering was committed to making things "for the use and convenience of man". But, for Tredgold, this was not simply a matter of <u>maintaining</u> things as they were. Engineering was supposed to "<u>improve</u> means of production and traffic". Engineering was, by definition, an instrument of material progress.

But what about engineering today? Most engineers would, no doubt, want to tinker with Tredgold's definition, for example, by substituting "people" for "man". But few, if any, would want to tamper with its core. Engineering remains an undertaking committed to human progress. So, for example, the most widely adopted of America's codes of engineering ethics, begins: "[Engineers uphold and advance the integrity, honor, and dignity of the engineering profession by] using their knowledge and skill for the <u>enhancement</u> of human welfare.[20]

IV.   Why Engineers are not Scientists

That is enough about engineering. We are ready to see how engineers differ from other technologists. Indeed, I have already pointed out some of the ways engineers differ from architects. I shall now explain how they differ from applied <u>scientists</u>.

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[19] Artz, 162.
[20] Accreditation Board of Engineering and Technology, Code of Engineering Ethics, first principle (1985).

I once did a workshop at the research lab of a large petroleum company. The audience was about half chemists and half chemical engineers. I first asked the chemists, "If you had a choice between inventing something useful and discovering new knowledge, which would you prefer?" The chemists thought this a hard question: "After all," they reasoned, "it's hard to imagine an interesting discovery in chemistry that would not have a practical pay-off." When I asked for a show of hands, about half the chemists voted for "something useful" and about half for "new knowledge". The engineers, on the other hand, all voted for usefulness. For them, new knowledge was just a means to improving human life.

Unlike chemists, engineers had no commitment to science as such. They used science, much as they used other sources of insight. They also contributed to science much as they have contributed to lawyering and other social practices, for example, by helping to develop computers. They did this as non-scientists, as participants in a voyage of invention rather than discovery.

This difference between engineers and chemists came as a surprise to these researchers. Many had worked side by side for decades. They thought that they shared the same values. But we do not wear our values on our clothing like an identity badge- except, of course, by declaring ourselves to be of this profession rather than of that. These researchers had not taken the difference in profession seriously. That is why they were surprised.

This difference between scientists and engineers is not simply a feature of industrial laboratories. I have asked the same question at university workshops attended by both engineering and science faculty. The results were even sharper. The only thing rarer than a university scientist who voted for "something useful" was an engineer who voted for "new knowledge". In this respect at least, engineers are not scientists, not even applied scientists. The primary commitment of engineers is not to knowledge, theoretical or applied, as one would expect of scientists, but to human welfare."[21]

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[21] Compare Vincenti, p. 161: "Engineers are after a theory they can use for practical calculations ...To obtain such a theory they are willing, when necessary, to forgo generality and precision... and to tolerate a considerable phenomenological component. Scientists are more likely to be out to test a theoretical hypothesis ...or infer a theoretical model."

V.   Ethics and Engineering

Earlier, I described engineering as a "new power in the world". Power, though neither good nor bad in itself, is always dangerous. Because of the scale on which engineers generally work, engineering is particularly dangerous. Engineers long ago realized this and set about to assure, as much as possible, that engineering would be used for good rather than evil. They organized as a profession, adopted a code of ethics, and tried to put that code into practice.

"Ethics" has at least three common uses. It can refer: first, to ordinary morality; second, to the systematic study of ordinary morality: but, third, to those special morally permissible standards of conduct every member of a group wants every other member to follow even if that would mean having to follow the standards too. It is in this third sense, I think, that members of a profession talk of their "profession's ethics"[22] In this sense, engineers did not have a code of ethics until they adopted one. In the United States, that was not until early in this century.

In this sense too, their code of ethics is what they make it—so long as the standards they lay down are consistent with ordinary morality. That means that engineering ethics can change over time and even differ from country to country or field to field.

There is, then, an important difference between values and ethics. While engineers generally seem to have valued human welfare since early in the history of engineering, ignoring human welfare could not be unethical (in my third sense of that term) until engineers adopted a standard of conduct forbidding them to ignore human welfare.

Values are reasons for acting, and so reasons for adopting standards of conduct, but values, as such, do not tell us how we should act. They only tell us this is something to consider. Standards of conduct do tell us how we should act. They tell us something different from values. So, it is important not to confuse values and ethics.

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[22] For some historical background on this use, as well as my rationale for preferring it, see my "The Ethics Boom: What and Why", Centennial Review 34 (Spring 1990): 163-186.

VI.   Conclusion

There is, of course, a good deal more I could say about ethics, especially about the ethical problems of the workplace or marketplace, what can lead people to do wrong there, and the various ways in which professions can help them do right. But I have said much about such things elsewhere"[23]; and, anyway, my time is gone. So, let me sum up:

Technology is often thought of as a relation among things, a product of knowledge over which humans have little or no control. I have tried to explain technology as a fundamentally human undertaking, the imperatives of which are themselves largely the work of humans.

I have focused on engineers not only because they are, in my view, now the chief agents of technology, but also because they are so often lumped with scientists and thereafter ignored. What engineers do is both too important and too interesting for that.

Last, I have mentioned two ways in which we can control technology: law, as in EPA regulations; and ethics, as in the engineers' code of ethics. I have, I hope, in this way provided a framework for thinking about technology, values, and ethics in the lectures to follow this one.

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[23] See, especially, "The Moral Authority of a Professional Code", NOMOS 29 (1987): 302-337; "The Use of Professions", Business Economics 22 (October 1987): 5-10; "Vocational Teachers, Confidentiality, and Professional Ethics", International Journal of Applied Philosophy 4 (Spring 1988): 11-20; "Professionalism Means Putting Your Profession First", Georgetown Journal of Legal Ethics (Summer 1988): 352-366; "Thinking Like an Engineer: The Place of a Code of Ethics in the Practice of a Profession", Philosophy and Public Affairs 20 (Spring 1991): 150-167; "Do Cops Really Need a Code of Ethics", Criminal Justice Ethics 10 (Summer/Fall 1991): 1428; and "Codes of Ethics, Professions, and Conflict of Interest", Professional Ethics 1 (Spring/Summer 1992): 179-195.