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The Autonomy of Technology

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It might seem that it is but one step from the view that technology is ideologically neutral to the view that technology is autonomous. If a tool or system can contribute to the decision-making process by forcing changes in values, then surely, it might be suggested, the system itself becomes an independent actor in the process. Maybe so, but probably not. But the view that technology is autonomous is a popular one. Consider what Jacques Ellul has to say on the subject:

- Technique is autonomous with respect to economics and politics

- Technique elicits and conditions social, political and economic change. It is the prime mover of all the rest, in spite of any appearance to the contrary and in spite of human pride, which pretends that man's philosophical theories are still determining influences and man's political regimes are decisive factors in technical evolution.[1]

Ellul may be right about the role philosophical theories and political regimes play in technical evolution, but his claims also sound somewhat exaggerated. More important, the kind of claim he makes for the autonomy of technology makes it sound as if it were unfalsifiable, especially given assertions such as "in spite of any appearance to the contrary."

Unfortunately, claims like Ellul's have become commonplace. They amount to treating technology as a kind of "thing," and in so doing they reify it, attributing causal powers to it and endowing it with a mind and intentions of its own. In addition to the fact that it is empirically false that *Technology* has these characteristics, reifying Technology moves the discussion, and hence any hope of philosophical progress, down blind alleys. The profit in treating Technology in

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this way, to the extent there is any, is only negative. It lies in removing the responsibility from human shoulders for the way in which we make our way around in the world. Now we can blame all the terrible things that happen to us on Technology! It is only after the first moves have been made toward reifying Technology that we hear about such things as the "threat" of technology taking over our lives. Likewise, reification leads to misleading talk about technology being the handmaiden to science, or some variant on that theme. In other words, reification makes talk about autonomy possible. But, I will argue, it is a major mistake to think there is any *useful* sense in which we could conceive of technology as autonomous.[2]

It is important to stress the "useful" here. It is no doubt possible to contrive outrageous examples to show there is something called autonomous technology. But before we allow misdirected philosophical analysis to take us into the world of science fiction, we can at least take the time to understand what is really going on. Technology, even understood in its more popular-culture sense as new gadgets and electronics, among other things, is such an integral part of our society and culture that unless we ferret out the ways in which these devices are actually embedded in our lives, we may fall victim to a kind of intellectual hysteria that makes successful dealings with the real world impossible. The first step to take if we are to avoid this danger is to clarify the kinds of issues that can reasonably be addressed. To a large degree this means separating the significant from the trivial.

TRIVIAL AUTONOMY

There are at least two cases of talk about the autonomy of technology that are non-starters. That is, if these popular topics of discussion are considered carefully, they easily can be shown to be irrelevant to serious consideration of the issue, since the kind of autonomy they address is trivial.

In the first case, some version of the following account is given of what it means for technology to be autonomous: technology is autonomous when the inventor of a technology, once the technology is made available, loses control over his or her invention. The development of the digital computer can be used as such an example. Once computers entered the public domain, it was impossible for anyone to call them back. The rapid increase in their sophistication and the all-pervasiveness of their employment in society made it impossible to avoid them once they entered the marketplace. Surely, the story goes, this is a case of autonomous technology.

Well, yes and no. Yes, it is autonomous, if by that is meant only that the inventor alone can no longer control the development of the technology. But this is a trivial sense of "autonomy," since it is true of all aspects of our society. Once in the public domain, each item is beyond the control of its inventor in some

sense or other. But that does not make the item autonomous. Its further development is a direct function of how people employ it and extend it. To the extent that people are necessarily involved in that process, the invention cannot be autonomous. Rather than being conceived of as an independent agent that acts on its own, the invention is seized opportunistically as a means to an end. It is used, changed, augmented, or discarded, depending on the goals of the agents. That these various uses were not envisioned or intended by its inventor does not make the invention autonomous in any interesting sense.

The second trivial case of autonomous technology concerns the consequences of innovation. Here it might be claimed, for instance, that because the inventor of a device or system failed to see the consequences of employing it in a certain way, the item has a life of its own and is autonomous. Thus it would appear on this scenario that the use of nuclear plants to generate electricity is evidence for the autonomy of nuclear energy, since this use was not foreseen by Einstein in his famous letter to President Roosevelt informing him of the wartime potential for nuclear energy. This, too, is an incorrect conclusion. The fact of the matter is that no one can foresee all the consequences of any act. That fact, however, does not entail that once some action is taken, the consequences of that action are autonomous. That the full consequences of introducing large-scale manufacturing techniques for the production of automobiles were not anticipated by Henry Ford does not mean that those consequences were due to the automobile or to the processes, economic, social, and engineering, that produced it.

The key to understanding this second point lies in realizing that once an invention or innovation leaves the hands of its inventor, it also leaves behind the circumstances in which the actions of only one person can affect its development and employment. Once it enters the public domain, its diffusion generally will be the result of community decisions; and as we noted these are the kinds of decisions that are the results of compromises. That there is no logical order to the patterns these decisions take should come as no surprise. Compromise is a function of a variety of factors, and it is impossible to tell in advance which of them will be persuasive in any given situation. Furthermore, it may be that *it is this lack of absolute predictability with respect to the outcome of community decisions that itself produces the illusion of the autonomy of technology.* But the fact that the role an innovation acquires in a society is a function of complicated community decisions, which decisions are at best compromises (at worst they are the result of collusion and corruption, which themselves involve compromise), does not entail that the innovation is autonomous. *Quite the contrary.* Given the kind of buffeting and manipulation this process involves, it would appear that it would be anything but autonomous!

Thus arguments from the eventual lack of control of the inventor and the failure to foresee all the consequences fail to secure the case for the "autonomy of technology." But there are also other arguments we need to consider.

THE PROCESS OF TECHNOLOGY

Well-intentioned writers and critics have commented on various aspects of technology which they see as raising the possibility of a serious sense of autonomous technology and, along with it, the specter of apocalypse. One of the best examples of the kind of worry expressed by these authors can be found in John McDermott's essay review of Emmanuel Mesthene's *Technological Change*, "Technology: The Opiate of the Intellectuals."[3] In that review McDermott speaks of a kind of momentum certain devices or systems acquire, thereby providing the appearance of autonomy.

Consider the following McDermottian scenario. A growing retail company located in Fairbanks has just hired a fancy up-to-date accountant with an MBA to manage the financial records of the company, which records are currently in a condition closely resembling chaos. Our accountant is a bright young urban professional. Given the size of the company and its projected growth, she argues persuasively that in the long run it will be cheaper and more efficient to buy a couple of computers than to hire additional staff and to continue handling the books in the traditional way, with ledgers entered by hand, etc. She produces a report showing the projected costs of people versus machines, calculating only for the long run the cost of benefits and retirement for the people and maintenance for the machines. She wins her case and the computers are purchased. But once the computers are introduced, air conditioning is not far behind, because the computers need a cool environment to function optimally. But, our fictional tale continues, air conditioning simply can't be added on to the current structure housing the company offices. Either we redesign the old building to handle air flow and pressure, or we look for a new one. Finally, our storyteller says with a knowing look, the president of the company is totally confused and dismayed and yells: "How did we get into this fix? The old building is perfectly good, we really don't need air conditioning in Alaska; since we introduced those machines, things have gotten out of control!"

This is a typical story—one often told and perhaps even representing a situation often experienced. But just because such stories are told, and some people may interpret their experiences in this fashion, it doesn't follow that they have lost control to some autonomous technology that has taken over their company. What the tale allows us to see is that despite the fact that machines play a prominent role in the unfolding sequence of events, the major overlooked fact is that people often tend to forget the reasons for which they introduced a certain kind of tool or procedure. Instead of taking time to assess critically the impact of making further accommodations to the tools, possibly even concluding that it may be time to reexamine the whole situation, people often simply "go with the flow" and take what appears to be the course of least resistance. Still, from the fact that people sometimes tend to react to the circumstances of a situation in certain ways, perhaps accommodating a new procedure at first, rather than either replacing it either with another or eliminating it altogether, it does not follow that the procedure is autonomous.

A basic point we sometimes tend to forget is that *there is no getting rid of tools, written large*. Humanity making its way around in the world is humanity using tools of wide variety and complexity, e.g., hammers, automobiles, governments, electricity. The tools we invent to help us survive and go beyond are essential—perhaps even to the concept of humanity. It isn't as if we can remove tools altogether and continue without them. When we introduce an implement or a complex system, it is to help us achieve a goal. If we find that the device produces results or side effects in conflict with other goals and/or values, we may replace it or modify it. Whichever we choose, devices, tools, and systems remain with us; they are part of how we go about making our way in the world. What McDermott overlooked (when he spoke of how technologies become so ingrained in our procedures that in accommodating the requirements of the technology we lose our independence of action) was that it is the *perception, or lack of it, that people have of the usefulness of a new product that determines the extent to which they are willing to make concessions in its direction*. They may also lose sight of the goal that first guided their actions and, therefore, may react blindly to the circumstance with which they are now faced. But that is not to say that the product has "taken over." For nothing *in principle* rules out later modifications and, if necessary, replacements. What is required is that the individuals involved keep their objectives in mind and be strong enough to act in their own best interests.

COMMON SENSE

Phrased as I have put it, technology conceived of as humanity at work represents the results of the systematic application of common sense; common sense is how people first gain experience and then knowledge by acting on that experience. Nor should this result come as a surprise. Since, if we acknowledge that the concept of a tool lies at the commonsense heart of technology, and if we accept the rather obvious point that not all tools are physical tools, i.e., that there are conceptual tools, social tools, economic tools, etc., then it is not difficult to agree that knowledge is a tool, and if knowledge is constantly being updated, the tool is constantly being honed. In other words, if science produces knowledge, then the knowledge science produces is constantly being upgraded and changed by virtue of the impact of various other tools on the efforts of science to discover more and more about the world. Or to put it differently, quite aside from the resolution of the question of the independence or interdependence of technology and science, if science produces knowledge, and if that knowledge is sometimes used to develop tools that are used in the world, then what those tools produce should generate a form of knowledge that ought to have a bearing in turn on the original knowledge that produced the tools. In addition, it follows that what we do and how we do it is also constantly changing in the face of these developments, and that is as it should be. The bottom line is that, on this account, once a relation between a science and some tool or procedure is established, neither can lay further claims to autonomy—the interdependence is an essential aspect of the process of science itself.[4] But this point of view cannot be established only by *a priori* argument. We need to look at what actually goes on; and I have selected a historical case study to illustrate my points. This is not to say that the analysis of one historical example will settle the issue, but it should help clarify some matters.

Indeed, the case I want to look at, Galileo and the telescope, ought to help exhibit just the issues relevant to sorting out some of the confusions surrounding the interrelations between the development of science and the use of tools and systems of tools. Furthermore, there is a punch line. The general thesis, as already expressed, is that science and technology—where "technology" should now be read as tools, techniques, and systems of tools and techniques—where they interact at all, are mutually nurturing. There is also a caveat, to wit, in point of fact some technologies are science-independent, e.g., the roads of Rome. This is not to say that they are autonomous, since those technologies were responses to needs and goals also; just not the needs and goals of some scientific theory. And some science generates no technology, e.g., Aristotelian biology. The punch line is this: once that is said, something of a paradox emerges. For the history of science is the history of failed theories. But the failure of theory most often does not force a discarding of whatever technology that theory generated or was involved with, nor does the failure of the theory force the abandoning of the technology if a technology was responsible for that theory. To oversimplify: sciences come and go, but their technologies remain. But oversimplification is what got us into trouble at the start, so a more accurate claim would be: scientific theories come and go, but some technologies with which they are in one way or another associated remain. It is also the case that some technologies associated with specific scientific descriptions disappear when they are replaced or superseded by new techniques.

But there is one sense in which the transient character of scientific theories becomes somewhat problematic. That is, if, as I put it earlier, technology is an integral part of science and partially responsible for changing the science, then the failure of the particular theories could be construed as a failure of the technology involved as well. This may in fact be true. But we should also emphasize that technology is seen as a process of policy formation, implement-system implementation, assessment, and updating, which process functions at a variety of levels and with varying degrees of significance for technologies further up and down the line; e.g., the initial failure of the Hubble to produce clear pictures of the heavens did not spell disaster for the entire project. Goal-achieving activities are nested within one another and, as we shall see, as a matter of historical and physical accident, the nesting will have different degrees of importance depending on the case. Thus placing the blame for a failed scientific theory on its associated technology once again oversimplifies the situation.

GALILEO AND THE TELESCOPE

To illustrate some of the notions introduced here, let us turn to an examination of the development of the telescope by Galileo and its effect on some of the theoretical problems he faced in his efforts to show that Copernicus's theory was worthy of serious scientific consideration. As we shall see, the story is not a simple one, and the issue takes on an increasing degree of complexity as the tale proceeds.

To begin with, we need to be perfectly clear that Galileo did not begin his work on the telescope in order to prove anything about Copernicus. The full story of how Galileo came to construct his first telescope is clearly and succinctly put forth by [Stillman] Drake in his *Galileo at Work*. There, quoting from a number of Galileo's letters and published works, Drake makes it clear that Galileo was first drawn to the idea of constructing a telescope out of financial need. To summarize the account: in July 1609 Galileo was in poor health and, as always, if not nearly broke at least bothered by his lack of money. Having heard of the telescope, Galileo claims to have thought out the principles on which it worked by himself, "my basis being the theory of refraction." Drake acknowledges that there was no theory of refraction at the time, but excuses Galileo's claim on the grounds that this was not the first time that Galileo arrived at a correct result by reasoning from false premises. (Historians of the logic of discovery, take note.) Once having reconstructed the telescope, Galileo writes: "Now having known how useful this would be for maritime as well as land affairs, and seeing it desired by the Venetian government, I resolved on the 25th of this month [August] to appear in the College and make a free gift of it to his Lordship."[6] The result of this gift was the offer of a lifetime appointment with a nice salary increase from 520 to 1000 florins per year. What was unclear at the time, and later became the source of major annoyance on Galileo's part, was that along with the stipend came the provision that there was also to be no further increase for life. So he reinitiated his efforts, eventually successful, to return to Florence.

Now there are some problems here that need not delay us, but they ought to be mentioned in passing. How Galileo managed to reconstruct the telescope from just having heard reports of its existence in Holland remains something of a mystery. Galileo provides us with his own account of the reasoning he followed; but, as Drake notes, his description has been ridiculed by historians because, despite the fact that the telescope he constructed worked, he did not quite think it through correctly. Nevertheless, Drake's observation, that "the historical question of discovery (or in this case, rediscovery) relates to results, not to rigorous logic," seems to the point.[7] Despite the fact that a telescope using two convex lenses can be made to exceed the power of one using a convex and a concave lens, the truth of the matter is that Galileo's telescope worked. On the other hand, this point about faulty reasoning leading to good results seems to tie into the paradoxical way in which technologies (thought of as artifacts of varying degrees of complexity and abstractness) emerge and remain with us. But more of this later.

We can now turn to the question of the impact of the telescope on Galileo's work. As he reports it, Galileo first turned his original eight-power telescope toward the moon in the presence of Cosimo, the Grand Duke of Florence. He and Cosimo apparently discussed the mountainous nature of the moon, and shortly after his return to Padua in late 1609, Galileo built a twenty-power telescope, apparently to confirm his original observations of the moon. He did so and then wrote to the Grand Duke's secretary to announce his results. So far then, Galileo has constructed the telescope for profit and is continuing to use it to advance his own position by courting Cosimo.

Galileo, never retiring about his work, continued to use the telescope and to make his new discoveries known through letters to close friends. Consequently, he also began to attract attention. But others such as Clavius now also had access to telescopes. That meant Galileo had to put his results before the public in order to establish his priority of discovery. Therefore, in March 1610 Galileo published *The Starry Messenger*, reporting his lunar observations as well as accounts of the Medicean stars and the hitherto unobserved density of the heavens. At this point controversy enters the picture. These reports of Galileo essentially challenge one of the fundamental assumptions of the Aristotelian theory of the nature of the heavenly sphere: its perfection and immutability. While the rotation of the Medicean stars around Jupiter can be shown to be compatible with both the Copernican and the Tychonian mathematical astronomies, it conflicts with the philosophical and metaphysical view that demands that the planets be carried about a stationary earth embedded in crystalline spheres. And to be clear about the way the battle lines were drawn, remember that Galileo's major opposition came primarily from the philosophers, not from the proto-scientists and other astronomers of his time.

The consequences of Galileo's telescopic observations were more far-reaching than even Copernicus's mathematical model. For the problems Copernicus set were problems in astronomical physics and, as such, had to do with meeting the observational restraints represented by detailed records of celestial activity. Galileo's results, however, and his further arguments concerning the lack of an absolute break between terrestrial and celestial phenomena, maintaining as they did the similarities between the moon and the earth, etc., forced the philosophers to the wall. It was the philosophers' theories that were being challenged when the immutability of the heavens was confronted with the Medicean stars, the phases of Venus, sunspots, and new comets. One might conclude, then, that this represented something akin to a radical Kuhnian paradigm switch.

Much has been written about the extent to which Kuhn's paradigm shifts and their purported likeness to Gestalt switches actually commit someone who experiences one to seeing a new and completely different world. But to see mountains on the moon in a universe in which celestial bodies are supposed to be perfectly smooth comes pretty close to making sense of what this extreme interpretation of Kuhn might mean. Prior to the introduction of the telescope, observations of the heavens, aside from providing inspiration for poets and lovers, were limited to supporting efforts to plot the movements of the planets against the rotation of the heavenly sphere. Furthermore, metaphysical considerations derived from Aristotle interfered with the conceptual possibility of learning much more, given the absence of alternatives. The one universally accepted tool that was employed in astronomical calculation was geometry, and its use was not predicated on any claims of realism for the mathematical models that were developed, another point derived from Aristotelian methodology. The acceptable problem for mathematical astronomy was to plot the relative positions of various celestial phenomena, not to try to explain them. Nor were astronomers expected to astound the world with new revelations about the population of the heavens, since that was assumed to be fixed and perfect. So whatever else astronomers were to do, it was not to discover new facts; there were not supposed to be any.

But the telescope revealed new facts. And for Galileo this meant that some way had to be found to accommodate them. Furthermore, to make the new telescopic findings acceptable, Galileo had to do more than merely let people look and see for themselves. The strategy he adopted was to link the telescopic data to something already secure in the minds of the community: geometry. This, however, was not as simple as it sounds. He had to build a case for extending geometry as a tool for physics, thereby releasing it from the restrictions under which it labored when used only as a modeling device for descriptive astronomy. In other words, Galileo had to advance the case of Archimedean mechanics. To this end he was forced to do two different things: (1) emphasize rigor in proof—extolling the virtues of geometry and decrying the lack of demonstrations by his opposition; and (2) de-emphasize the appeal to causes in providing explanations of physical phenomena (since abandoning the Aristotelian universe entailed abandoning the metaphysics of causes and teleology—without which the physics was empty).

GEOMETRY AS A TECHNOLOGY

This is not the place to detail the actual way in which Galileo employed geometry to radicalize the notions of proof, explanation, and evidence.[8] Suffice it to say that he did and that it met with mixed success. The general maneuver was to begin by considering a problem of terrestrial physics, proceed to "draw a little picture," analyze the picture using the principles of Euclidean geometry, and (1) interpret the geometric proof in terrestrial terms, just as a logical positivist would interpret an axiomatic system *via* a "neutral" observation language, and then (2) extend the terrestrial interpretation to celestial phenomena. This is how he proceeded with his account of mountains on the moon, namely by establishing an analogy with terrestrial mountains. This process took place in stages. He first subjected the terrestrial phenomena to geometric analysis and then he extended that analysis to the features of the moon. Not all of Galileo's efforts at explanation using this method succeeded, e.g., his account of the tides. Nevertheless, the central role of geometry cannot be denied.

While Galileo used geometry for most of his career, it was not until he was forced to support publicly his more novel observations and hypotheses that we find in his writings the beginnings of what was eventually to become a very sophisticated methodological process. This procedure is most clearly evident in his last two works, the *Dialogue on the Two Chief World Systems* and his *Discourses on Two New Sciences*. But in the end the *geometric method* as employed by Galileo, or to put it more specifically, Galilean science, dies with Galileo. No one significant carried on his research program using his methods. Whatever impetus he gives to mathematics in science, his mathematics, geometry, very quickly gives way to Newton's calculus and the mathematics of the modern era.

Galileo's use of geometry was as much the employing of a technology conceived of as a tool/technique as was his use of the telescope. Furthermore, it represents the first major step toward the mathematization of what today we would call science. This much is commonplace. The challenging part comes in two sections. (1) The telescope was a new technology, whose introduction for primarily nonscientific reasons, i.e., money, was in fact science-independent, i.e., its invention by the Dutch was theory-independent. (The inventor, Hans Lipperhey, was a lens grinder; the invention was apparently the result of simply fooling around with a couple of lenses, the basic properties of which were known through Lipperhey's daily experience.) In many ways, the use of this new technology by Galileo can be held responsible for the extension of the *geometric method* as a radical method of supporting knowledge claims. (2) Geometry was also theory-independent. But, unlike the telescope, geometry was a very old technology. It was called upon to rescue, as it were, the new technology. It was a very different kind of technology from the telescope, being a method for providing justifications, i.e., proofs, of abstract conclusions regarding spatial relations, not a physical thing. Furthermore, despite the fact that this old technology was required to establish the viability of the new, the old was soon to become obsolete with respect to the justificatory role it was to play in science. That it was to be replaced also had nothing to do with any significant relation between the telescope and the development of the theory Newton outlined in his *Principia*. In other words, the telescope itself had little direct bearing on the development of the calculus, and yet it was the calculus that superseded geometry (but did not completely eliminate it) as the mathematical basis for scientific proof.

TECHNOLOGY AND THE DYNAMICS OF CHANGE: AUTONOMY SOCIALIZED

If we try to sort it all out, the results are uncomfortable for standard views of technology and the growth of knowledge. The two technologies remain, the two

sciences have been replaced. Furthermore, in one of the truly nice bits of irony that history reveals, one of the superceded technologies, geometry, after being replaced by a different kind of mathematical system for justificatory functions, experiences a resurrection in the nineteenth century and ends up playing a crucial role (but not a justificatory role) in the development of yet another physics, having been modified and expanded in the process.

Where is the autonomy here? Both Galileo's physics and the telescope, while capable of being viewed as independent products of one man's creative energy, can also be seen performing an intricate *pas de deux* of motivation and justification when the process of inquiry is examined. It is getting difficult to determine which view ought to take priority. A resolution of the problem might be found if we stop looking at the history and examine the concept of "autonomy" itself.

If we define "autonomous" as "free from influence in both its development and its use," then technology cannot be autonomous since it is inherently something used to accomplish specific goals. But what happens if we try to define "technology" so as to allow technology to have an impact on us as well as on our environment? Are we then committed to the view that, given a technology in use, there emerges from its use a self-propagating process outside the control of humankind? If (1) technology, is a product, and (2) we do not add some additional properties to technology beyond its being a thing we manipulate, then (3) there is no reason why we should even begin to think of technology as not within our control.

In other words, we can talk of Galileo being forced to employ geometry and to develop novel methods of justification in order to defend his telescopic discoveries, for what sense does "forced" carry here? The telescope did not with logical necessity precipitate him headlong into battle. Much of what Galileo did to defend his claims and insure his priority of discovery was the product of his flamboyant personality. This was a man who loved fights and being in the public eye. How these features of Galileo's personality can be factored into the tool so as to make it appear that the tool itself is responsible for the action of the man is beyond serious consideration. Given the tool, we can plot its history. What that history amounts to is how it is used. How it is used is a complicated process, for it can entail more than intentional application of a device. "Use" may also mean "rely on," and it may be the case that what we rely on we take for granted, never giving thought to the cost. But this does not thereby entail that, in the absence of human deliberation, the tool by default acquires intentionality and, along with it, control of human affairs.

An alternative would be to endorse the idea that both the telescope and geometry used Galileo. This suggests a science fiction scenario in which as soon as any technology is used by a person, it "takes over" that individual. In the case of populations adopting constitutions that establish governments, all freedom of human action is lost since the government "takes over." Surely this amounts to a *reductio*. For the tool used to adopt government is reason. Is reason, too, going to be something sufficiently alien that we should fear it? The image really does become Mephistophelian enough that we ought to worry about the extent to which we have lost touch with reality.

Further, the existence of a technology does not entail that it will be used. We all know people who refuse to use computers today, not because they cannot, but simply because they feel more comfortable with the old technology of pen and paper. Surely we do not want to say that these individuals are controlled by pencil and paper. The decision to employ a certain means to an end requires thought, information, a determination of the nature and desirability of the end, assessment of the long- and short-term costs and benefits, as well as constant updating of the database. What if, in his declining years, our pen-and-pencil advocate changes his mind and opts for the computer, having decided that time is running out and he has too many things to finish by hand? Do we really want to say that the machine won out over man? Surely not; the man initiated the process that led to the machine, so why not include him in that process?

We are at the point where, in closing, we might ask: Why are we so quick to point to the machines and wag our finger? Well, the long and the short of it is that those who fear reified technology really fear men. It is not the machine that is frightening, but what some men will do with the machine; or, given the machine, what we fail to do by way of assessment and planning. It may be only a slogan, but there is a ring of truth to: "Guns don't kill, people do." There is no problem about the autonomy of technology. Pogo was right: "We have met the enemy and he is us."[9] The tools by themselves do nothing. That, I propose, is the only significant sense of autonomy you can find for technology.

NOTES

1. Jacques Ellul, *The Technological Society* (New York: Vintage Books, 1964), p. 133

2. For examples of this "style" of philosophizing about technology, see Ellul, *The Technological Society* and Langdon Winner, *Autonomous Technology: Technics-Out-of-Control as a Theme in Political Thought* (Boston: Kluwer Academic Publishers, 1977).

3. John McDermott, "Technology: The Opiate of the Intellectuals," *New York Review of Books*, July 31, 1969, 25–35.

4. See John Dewey, *The Quest for Certainty* (New York: Minton, Balch, 1929) for the development of a similar argument.

5. As quoted in Stillman Drake, *Galileo at Work* (Chicago: University of Chicago Press, 1978), p. 139.

6. As quoted in Drake, *Galileo at Work*, p. 141, Galileo's letter to his brother-in-law Bendetto Landucci.

7. Drake, *Galileo at Work*, p. 140.

8. I have worked on the topic. See my "Galileo: Causation and the Use of Geometry," in *New Perspectives on Galileo*, ed. R.E. Butts and J. C. Pitt (Dordrecht: D. Reidel,

1978); "The Role of Inductive Generalizations in Sellar's Theory of Explanation," *Theory and Decision* 13 (1982): 345–56; "The Character of Galilean Evidence," *PSA* (1986): 125–34; and *Galileo, Human Knowledge, and the Book of Nature: Method Replaces Metaphysics* (Dordrecht: Kluwer, 1991). Also see Ernan McMullin, *Galileo, Man of Science* (New York: Basic Books, 1968); William Shea, *Galileo's Intellectual Revolution* (London: Macmillan, 1972); and William A. Wallace, *Galileo's Logic of Discovery and Proof: The Background Content and Use of His Appropriated Treatises on Aristotle's Posterior Analytics* (Boston: Kluwer Academic Publishers, 1992); among others.

9. Quoted in Walt Kelly, *Outrageously Pogo*, eds. Mrs. Walt Kelly and Bill Crouch Jr. (New York: Simon and Schuster, 1985), p. 114.