*Part II.*

# DEMOCRATIC RATIONALIZATION





## 4. The Limits of Technical Rationality

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from Questioning Technology

### TECHNOLOGY AND DEMOCRACY

A great deal of 20th century social thought has been based on a pessimistic view of modernity that achieved its classic expression in Max Weber's theory of rationalization. According to Weber, modernity is characterized by the increasing role of calculation and control in social life, a trend leading to what he called the "iron cage" of bureaucracy (Weber, 1958: 181-182). This notion of enslavement by a rational order inspires pessimistic philosophies of technology according to which human beings have become mere cogs in the social machinery, objects of technical control in much the same way as raw materials and the natural environment. While this view is overdrawn, it is true that as more and more of social life is structured by technically mediated organizations such as corporations, state agencies, prisons, and medical institutions, the technical hierarchy merges with the social and political hierarchy.

The idea and (for some) ideal of technocracy grows out of this new situation. Technocracy represents a generalization to society as a whole of the type of "neutral" instrumental rationality supposed to characterize the technical sphere. It assumes the existence of technological imperatives that need only be recognized to guide management of society as a system. Whether technocracy is welcomed or abhorred, these deterministic premises leave no room for democracy.

The title of this part of this book implies a provocative reversal of Weber's conclusions. "Democratic" rationalization is a contradiction in Weberian terms. On those terms, once tradition has been defeated by modernity, radical struggle for freedom and individuality degenerates into an affirmation of irrational life forces against the routine and drab predictability of a bureaucratic order. This is not a democratic program but a romantic anti-dystopian one, the sort of thing that is already foreshadowed in Dostoievsky's *Notes from Underground* and various back to nature ideologies. The new left and all its works have been condemned repeatedly on these grounds.

No doubt the new left is rightly criticized for the excesses of its romanticism, but the two preceding chapters of this book show that this is not the whole story. Modern societies experienced real crises in the late 1960s that marked a turning point in the willingness of the public to leave its affairs in the hands of experts. Out of that period came not just regressive fantasies but a new and more democratic conception of progress. I have attempted in several previous books to articulate that conception in a third position that is neither technocratic nor romantic. The crux of the argument is the claim that technology is ambivalent, that there is no unique correlation between technological advance and the distribution of social power. The ambivalence of technology can be summarized in the following two principles.

1. Conservation of hierarchy: social hierarchy can generally be preserved and reproduced as new technology is introduced. This principle explains the extraordinary continuity of power in advanced capitalist societies over the last several generations, made possible by technocratic strategies of modernization despite enormous technical changes.[1]

2. Democratic rationalization: new technology can also be used to undermine the existing social hierarchy or to force it to meet needs it has ignored. This principle explains the technical initiatives that often accompany the structural reforms pursued by union, environmental, and other social movements.

This second principle implies that there will generally be ways of rationalizing society that democratize rather than centralize control. We need not go underground or native to escape the iron cage. In this chapter and the next I will show that this is in fact the meaning of the emerging social movements to change technology in a variety of areas such as computers, medicine, and the environment.

But does it make sense to call the changes these movements advocate *rationalizations*? Are they not irrational precisely to the extent that they involve citizens in the affairs of experts? The strongest objections to democratizing technology come from those experts, who fear the loss of their hard-won freedom from lay interference. Can we reconcile public participation with the autonomy of professional technical work? Perhaps, as advocates of technocracy argue, we should strive not to politicize technology but to technicize politics in order to overcome the irrationality of public life. The counter-argument in favor of democratization must establish the rationality of informal public involvement in technical change.

[1] This principle explains why there can be no technical "fix" to fundamental social and political injustices. For examples, see Rybczynski (1991: chap. 5).



## FROM DETERMINISM TO CONSTRUCTIVISM

### *Determinism Defined*

Faith in progress has been supported for generations by two widely held deterministic beliefs: that technical necessity dictates the path of development, and that that path is discovered through the pursuit of efficiency.[2] So persuasive are these beliefs that even critics of progress such as Heidegger and Ellul share them. I will argue here that both beliefs are false, and that, furthermore, they have anti-democratic implications.

Determinism claims that technologies have an autonomous functional logic that can be explained without reference to society. Technology is presumably social only through the purpose it serves, and purposes are in the mind of the beholder. Technology would thus resemble science and mathematics by its intrinsic independence of the social world. Yet unlike science and mathematics, technology has immediate and powerful social impacts. Society's fate seems to be at least partially dependent on a nonsocial factor which influences it without suffering a reciprocal influence.

Determinism is based on two premises which I will call *unilinear progress* and *determination by the base*.

1) Technical progress appears to follow a unilinear course, a fixed track, from less to more advanced configurations. Each stage of technological development enables the next, and there are no branches off the main line. Societies may advance slowly or quickly, but the direction and definition of progress is not in question. Although this conclusion seems obvious from a backward glance at the history of any familiar technical object, in fact it is based on two claims of unequal plausibility: first, that technical progress proceeds from lower to higher levels of development; and second, that that development follows a single sequence of necessary stages. As we will see, the first claim is independent of the second and not necessarily deterministic.

2) Technological determinism also affirms that social institutions must adapt to the "imperatives" of the technological base. This view, which no doubt has its source in a certain reading of Marx, is long since the common sense of the social sciences. Adopting a technology necessarily constrains one to adopt certain practices that are connected with its employment. Railroads require scheduled travel. Once they are

[2] For an interesting recent collection of articles on determinism, see Smith and Marx (1994). The contribution of Philip Scranton seems closest in spirit to the theory presented here.

introduced people who formerly could live with rather approximate notions of time—the day marked out by church bells and the sun—need watches. So the imperative consequence of railroads is a new organization of social time. Similarly factories are hierarchical institutions and set the tone for social hierarchy throughout modern societies. Again, there is something plausible about this view, namely that devices and practices are congruent, but the stream of influence is not unidirectional.

These two theses of technological determinism present decontextualized, self-generating technology as the foundation of modern life. And since we in the advanced countries stand at the peak of technological development, the rest of the world can only follow our example. Determinism thus implies that our technology and its corresponding institutional structures are universal, indeed, planetary in scope. There may be many forms of tribal society, many feudalisms, even many forms of early capitalism, but there is only one modernity and it is exemplified in our society for good or ill. Late developers take note: as Marx once said, calling the attention of his backward German compatriots to British advances: "*De te fabula narratur*"— of you the tale is told (Marx, 1906: 13).

### *Underdetermination*

The implications of determinism appear so obvious that it is surprising to discover that neither of its two premises withstand close scrutiny. Yet contemporary sociology undermines the idea of unilinear progress while historical precedents are unkind to determination by the base.

Recent constructivist sociology of technology grows out of the new social studies of science. The "strong program" in sociology of knowledge challenges the exemption of scientific theories from the sort of sociological examination to which we submit nonscientific beliefs. The "principle of symmetry" holds that all contending beliefs are subject to the same type of social explanation regardless of their truth or falsity. This view derives from the thesis of underdetermination, the so-called Duhem-Quine principle in philosophy of science, which refers to the inevitable lack of logically compelling reasons for preferring one competing scientific theory to another (Bloor, 1991). Rationality, in other words, does not constitute a separate and self-sufficient domain of human activity.

A similar approach to the study of technology denies that a purely rational criterion such as technical effectiveness suffices to account for the success of some innovations and the failure of others. Of course it



remains true that some things really work and others do not: successful design respects technical principles. But there are often several possible designs with which to achieve similar objectives and no decisive technical reason to prefer one to the others. Here, underdetermination means that technical principles alone are insufficient to determine the design of actual devices.

What then does decide the issue? A commonplace reply is "economic efficiency." But the problem is trickier than it seems at first. Before the efficiency of a process can be measured, both the type and quality of output have to be fixed. Thus economic choices are necessarily secondary to clear definitions of both the problems to which technology is addressed and the solutions it provides. But clarity on these matters is often the outcome rather than the presupposition of technical development. For example, MS DOS lost the competition with the Windows graphical interface, but not before the very nature of computing was transformed by a change in the user base and in the types of tasks to which computers were dedicated. A system that was more efficient for programming and accounting tasks proved less than ideal for secretaries and hobbyists interested in ease of use. Thus economics cannot explain but rather follows the trajectory of development.

Constructivism argues, I think correctly, *that the choice between alternatives ultimately depends neither on technical nor economic efficiency, but on the "fit" between devices and the interests and beliefs of the various social groups that influence the design process.* What singles out an artifact is its relationship to the social environment, not some intrinsic property.

Pinch and Bijker illustrate this approach with the early evolution of the bicycle (Pinch and Bijker, 1987). In the late 19th Century, before the present form of the bicycle was fixed, design was pulled in several different directions. The object we take to be a self-evident "black box" actually started out as two very different devices, a sportsman's racer and a means of transportation. Some customers perceived bicycling as a competitive sport, while others had an essentially utilitarian interest in getting from here to there. Designs corresponding to the first definition had high front wheels that were rejected as unsafe by riders of the second type, who preferred designs with two equal-sized low wheels. The large diameter front wheel of the sportsman's racer was faster, but it was unstable. Equal-sized wheels made for a safer but less exciting ride. These two designs met different needs and were in fact different technologies with many shared elements. Pinch and Bijker call this original ambiguity of the object designated as a "bicycle," "interpretative flexibility."

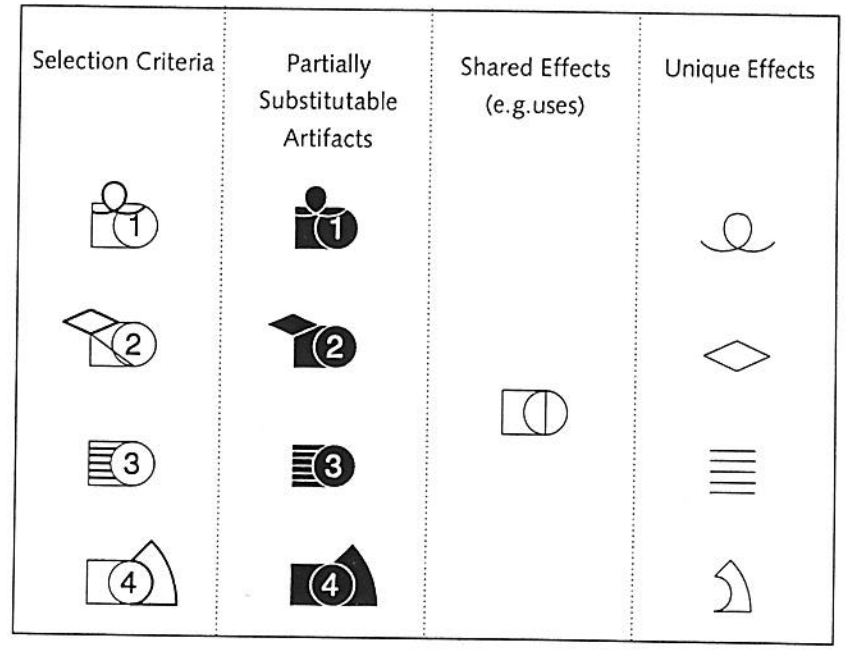
Eventually the "safety" design won out, and it benefited from all the subsequent advances in the field. The entire later history of the bicycle down to the present day stems from that line of technical development. In retrospect, it seems as though the high wheelers were a clumsy and less efficient stage in a progressive development leading through the old "safety" bicycle to current designs. In fact the high wheeler and the safety shared the field for years and neither was a stage in the other's development. The high wheeler represented a possible alternative path of bicycle development that addressed different problems.

The bicycle example is reassuringly innocent as are, no doubt, the majority of technical decisions. But what if the various technical solutions to a problem have different effects on the distribution of power and wealth? Then the choice between them is political and the political implications of that choice will be embodied in some sense in the technology. Of course the discovery of this connection did not await constructivism. Langdon Winner offers a particularly telling example of it (Winner, 1986: 22-23). Robert Moses' plans for an early New York expressway included overpasses that were a little too low for city buses. Poor people from Manhattan, who depended on bus transportation, were thereby discouraged from visiting the beaches on Long Island. In this case a simple design specification contained a racial and class bias. We could show something similar with many other technologies, the assembly line for example, which exemplifies capitalist notions of control of the work force. Reversing these biases would not return us to pure, neutral technology, but would simply alter its valuative content in a direction more in accord with our own preferences and therefore less visible to us.

Determinism ignores these complications and works with decontextualized temporal cross-sections in the life of its objects. It claims implausibly to be able to get from one such momentary configuration of the object to the next on purely technical terms. But in the real world all sorts of attitudes and desires crystallize around technical objects and influence their development. Differences in the way social groups interpret and use the objects are not merely extrinsic but make a difference in the nature of the objects themselves. Technology cannot be determining because the "different interpretations by social groups of the content of artefacts lead via different chains of problems and solutions to different further developments" (Pinch and Bijker, 1987: 42). *What* the object *is* for the groups that ultimately decide its fate determines what it *becomes* as it is modified. If this is true, then technological development is a social process and can only be understood as such.



Chart 2: How Artifacts Have Politics




Artifacts 1-4 share certain effects but each also has its own unique effects which distinguish it from the others. Effects in this sense include uses, contextual requirements that must be met to employ the artifacts, and their unintended consequences. Criteria 1-4 all select the shared effects of the artifacts and each also valorizes one or another of the unique effects. Where different unique effects have different political consequences, competing groups will have preferred criteria corresponding to the fit between their goals and the various artifacts. The criteria can also be combined in the course of the evolution of the artifacts through design changes that adapt one of them to also delivering the unique effects of one or several others. In a political context such combinations correspond to alliances.

Determinism is a species of Whig history which makes it seem as though the end of the story were inevitable from the very beginning. It projects the abstract technical logic of the finished object back into its origins as a cause of development, confounding our understanding of the past and stifling the imagination of a different future. Constructivism can open up that future, although its practitioners have hesitated so far to engage the larger social issues implied in their method.

*Indeterminism*

If the thesis of unilinear progress falls, the collapse of the notion of determination by the technological base cannot be far behind. Yet it is still frequently invoked in contemporary political debates. I shall return to these debates later in this chapter. For now, let us consider the remarkable anticipation of current conservative rhetoric in the struggle over the length of the workday and child labor in mid-19th Century England. Factory owners and economists denounced regulation as inflationary; industrial production supposedly required children and the long workday. One member of parliament declared that regulation is "a false principle of humanity, which in the end is certain to defeat itself." The new rules were so radical, he concluded, as to constitute "in principle an argument to get rid of the whole system of factory labor" (*Hansard's Debates*: 1844 (22 Feb-22 April), 1123, 1120). Similar protestations are heard today on behalf of industries threatened with what they call environmental "Luddism."

Yet what actually happened once limitations were imposed on the workday and children expelled from the factory? Did the violated imperatives of technology exact a price? Not at all. Regulation led to an intensification of factory labor that was incompatible with the earlier conditions in any case. Children ceased to be workers and were redefined socially as learners and consumers. Consequently, they entered the labor market with higher levels of skill and discipline that were soon presupposed by technological design and work organization. As a result no one is nostalgic for a return to the good old days when inflation was held down by child labor. That is simply not an option.[3]

This case shows the tremendous flexibility of technical systems. They are not rigidly constraining but on the contrary can adapt to a variety of social demands. The responsiveness of technology to social redefinition explains its adaptability. On this account technology is just another dependent social variable, albeit an increasingly important one, and not the key to the riddle of history.

Determinism, I have argued, is characterized by the principles of unilinear progress and determination by the base; if determinism is

[3] It is interesting (and distressing) to note the moral tensions around the use of child labor to manufacture imports such as sports shoes or circuit boards. In this as in so many other domains, globalization makes it possible to evade regulations that cannot be challenged on home territory. Predictably, political protests here against child labor abroad are weaker than would be resistance to reintroducing child labor at home.



wrong, then research must be guided by two contrary principles. In the first place, technological development is not unilinear but branches in many directions, and could reach generally higher levels along several different tracks. And, secondly, social development is not determined by technological development but depends on both technical and social factors.

The political significance of this position should also be clear by now. In a society where determinism stands guard on the frontiers of democracy, indeterminism is political. If technology has many unexplored potentialities, no technological imperatives dictate the current social hierarchy. Rather, technology is a site of social struggle, in Latour's phrase, a "parliament of things" on which political alternatives contend.

## CRITICAL CONSTRUCTIVISM

*Technology Study*

The picture sketched so far requires a significant change in our definition of technology. It can no longer be considered as a collection of devices, nor, more generally, as the sum of rational means. These definitions imply that technology is essentially nonsocial.

Perhaps the prevalence of such tendentious definitions explains why technology is not generally considered an appropriate field of humanistic study; we are assured that its essence lies in a technically explainable function rather than a hermeneutically interpretable meaning. At most, humanistic methods might illuminate extrinsic aspects of technology, such as packaging and advertising, or popular reactions to controversial innovations such as nuclear power or surrogate motherhood. Of course, if one ignores most of its connections to society, it is no wonder technology appears to be self-generating. Technological determinism draws its force from this attitude.

The constructivist position has very different implications for the humanistic study of technology. They can be summarized in the following three points:

1. Technical design is not determined by a general criterion such as efficiency, but by a social process which differentiates technical alternatives according to a variety of case-specific criteria;

2. That social process is not about fulfilling "natural" human needs, but concerns the cultural definition of needs and therefore of the problems to which technology is addressed;

3. Competing definitions reflect conflicting visions of modern society realized in different technical choices.

The first point widens the investigation of social alliances and conflicts to include technical issues which, typically, have been treated as the object of a unique consensus. The other two points imply that culture and ideology enter history as effective forces not only in politics, but also in the technical sphere. These three points thus establish the legitimacy of applying the same methods to technology that are employed to study social institutions, customs, beliefs, and art. With such a hermeneutic approach, the definition of technology expands to embrace its social meaning and its cultural horizon.

### *Function or Meaning*

The role of social meaning is clear in the case of the bicycle. The very definition of the object was at stake in a contest of interpretations: was it to be a sportsman's toy or a means of transportation? It might be objected that this is merely a disagreement over function with no hermeneutic significance. Once a function is selected, the engineer has the last word on its implementation and the humanist interpreter is out of luck. This is the view of most engineers and managers; they are at home with "function" but have no place for "meaning."

In chapter 9 I will propose a very different model of the essence of technology based not on the distinction of the social and the technical, but crosscutting the customary boundaries between them. In this conception, technology's essence is not an abstraction from the contingencies of function, a causal structure that remains the same through the endless uses to which devices are subjected in the various systems that incorporate them. Rather, the essence of technology is abstracted from a larger social context within which functionality plays a specific limited role. Technologies do of course have a causal aspect, but they also have a symbolic aspect that is determining for their use and evolution. From that standpoint, I would like to introduce Bruno Latour's and Jean Baudrillard's quite different but complementary proposals for what I will call a *hermeneutics of technology.*

Latour argues that norms are not merely subjective human intentions but that they are also realized in devices. This is an aspect of what he calls the symmetry of humans and nonhumans which he adds to the constructivist symmetry of true and false theories, successful and unsuccessful devices.



According to Latour, technical devices embody norms that serve to enforce obligations. He presents the door closer as a simple example. A notice posted on a door can remind users to close it, or a mechanism can close it automatically. The door closer, in some sense, does the work of the notice but more efficiently. It materializes the moral obligation to close the door too easily ignored by passersby. That obligation is "delegated" to a device in Latour's sense of the term. According to Latour, the "morality" in this case can be allocated either to persons—by a notice—or to things—by a spring (Latour, 1992). This Latourian equivalent of Hegelian *Sittlichkeit* opens the technical world to investigation not simply as a collection of functioning devices determined by causal principles but also as the objectification of social values, as a cultural system.

Baudrillard suggests a useful approach to the study of the aesthetic and psychological dimensions of this "system of objects" (Baudrillard, 1968). He adapts the linguistic distinction between denotation and connotation to describe the difference between the functions of technical objects and their many other associations. For example, automobiles are means of transportation—a function; but they also signify the owner as more or less respectable, wealthy, and sexy—connotations. The engineer may think these connotations are extrinsic to the device he or she is working on, but they too belong to its social reality.

Baudrillard's approach opens technology to quasi-literary analysis. Indeed, technologies are subject to interpretation in much the same way as texts, works of art, and actions (Ricoeur, 1979).[4] However, his model still remains caught in the functionalist paradigm insofar as it takes the distinction between denotation and connotation for granted. In reality, that distinction is a product not a premise of technical change. There is often no consensus on the precise function of new technologies. The personal computer is a case in point; it was launched on the market with infinite promise and no applications. The story of Chinese sea faring in the 15th century offers another marvelous example of prolonged suspense regarding function. The Chinese built the largest fleet composed of the biggest ships the world had ever seen, but could not agree on the purpose of their own naval achievements. Astonishingly, they dismantled the fleet and retreated into their borders, paving the way for the European conquest of Asia (Levathes, 1994: 20).

[4] Two interesting studies that illustrate this thesis around problems of lighting and electricity are Schivelbusch (1988) and Marvin (1988).

In the case of well established technologies, the distinction between function and connotation is usually fairly clear. There is a tendency to project this clarity back into the past and to imagine that the technical function of a device called it into being. However, as we have seen, technical functions are not pregiven but are discovered in the course of development and use. Gradually they are locked in by the evolution of the social and technical environment, as for example the transportation functions of the automobile have been institutionalized in low-density urban designs that create the demand for transportation automobiles satisfy. So long as no institutional lock-in ties it decisively to one of its several possible functions, these ambiguities in the definition of a new technology pose technical problems which must be resolved through interactions between designers, purchasers and users.

### *Technological Hegemony*

Technical design responds not only to the social meaning of individual technical objects, but also incorporates broader assumptions about social values. The cultural horizon of technology therefore constitutes a second hermeneutic dimension. It is one of the foundations of modern forms of social hegemony. As I will use the term, hegemony is domination so deeply rooted in social life that it seems natural to those it dominates. One might also define it as that aspect of the distribution of social power which has the force of culture behind it.

The term "horizon" refers to culturally general assumptions that form the unquestioned background to every aspect of life. Some of these support the prevailing hegemony. For example, in feudal societies, the "chain of being" established hierarchy in the fabric of God's universe and protected the caste relations of the society from challenge. Under this horizon, peasants revolted in the name of the King, the only imaginable source of power. Technocratic rationalization plays an equivalent role today, and technological design is the key to its cultural power.

Technological development is constrained by cultural norms originating in economics, ideology, religion, and tradition. I discussed earlier how assumptions about the age composition of the labor force entered into the design of 19th century production technology. Such assumptions seem so natural and obvious they often lie below the threshold of conscious awareness. When one looks at old photos of child factory workers, one is struck by the adaptation of machines to their height (Newhall, 1964: 140). The images disturb us, but were no doubt taken for granted until child labor became controversial. Design specifications simply incorporated the sociological fact of child labor into the structure of devices. The impress of social relations can be traced in the technology.

The assembly line offers another telling instance (Braverman, 1974). Its technologically enforced labor discipline increases productivity and profits by increasing control through deskilling and pacing work. However, the assembly line only appears as technical progress in a specific social context. It would not look like an advance in an economy based on workers' councils in which labor discipline was largely self-imposed by the work group rather than imposed from above by management. In such a society engineers would seek different ways of increasing productivity. Here again design mirrors back the social order (Noble, 1984). Thus what Marcuse called "technological rationality" and Foucault the "regime of truth" is not merely a belief, an ideology, but is effectively incorporated into the machines themselves.

Technologies are selected by the dominant interests from among many possible configurations. Guiding the selection process are social codes established by the cultural and political struggles that define the horizon under which the technology will fall. Once introduced, technology offers a material validation of that cultural horizon. Apparently neutral technological rationality is enlisted in support of a hegemony through the bias it acquires in the process of technical development. The more technology society employs, the more significant is this support. The legitimating effectiveness of technology depends on unconsciousness of the cultural-political horizon under which it was designed. A critical theory of technology can uncover that horizon, demystify the illusion of technical necessity, and expose the relativity of the prevailing technical choices.

### *Technical Regimes and Codes*

Disputes over the definition of technologies are settled by privileging one among many possible configurations. This process, called closure, yields an "exemplar" for further development in its field (van den Belt and Rip, 1990: 140). The exemplar reacts back on the technical discipline from which it originated by establishing standard ways of looking at problems and solutions. These are variously described by social scientists as "technological frames" or "technological regimes" or "paradigms" (Bijker, 1987: 168; Nelson and Winter, 1982: 258-259; Dosi, 1982). Rip and Kemp, for example, define a regime as:

> The whole complex of scientific knowledge, engineering practices, production process technologies, product characteristics, skills and procedures, and institutions and infrastructures that make up the totality of a technology. A technological regime is thus the technology-specific context of a technology which prestructures the kind of problem-solving activities that engineers are likely to do, a structure that both enables and constrains certain changes (Rip and Kemp, 1998: 340).

Such regimes incorporate many social factors expressed by technologists in purely technical language and practices. I call those aspects of technological regimes which can best be interpreted as direct reflections of significant social values the "technical code" of the technology. *Technical codes define the object in strictly technical terms in accordance with the social meaning it has acquired.* These codes are usually invisible because, like culture itself, they appear self-evident. For example, if tools and workplaces are designed today for adult hands and heights, that is only because children were expelled from industry long ago with design consequences we now take for granted. Technological regimes reflect this social decision unthinkingly, as is normal, and only social scientific investigation can uncover the source of the standards in which it is embodied.

Technical codes include important aspects of the basic definition of many technical objects insofar as these too become universal culturally accepted features of daily life. The telephone, the automobile, the refrigerator and a hundred other everyday devices have clear and unambiguous definitions in the dominant culture: we know exactly what they are insofar as we are acculturated members of our society. Each new instance of these standard technologies must conform to its defining code to be recognizable and acceptable. But there is nothing obvious about this outcome from a historical point of view. Each of these objects was selected from a series of alternatives by a code reflecting specific social values.

The bicycle reached this point in the 1890s. A technical code defining the bicycle as a safe means of transportation required a seat positioned well behind a small front wheel. The bicycle produced according to this code, known at the time as a "safety," became the forebear of all future designs. The safety connoted women and mature riders, trips to the store, and so on, rather than racing and sport. Eventually the safety was able to incorporate the racing connotations of the bicycle in specialized designs and the old high wheeler was laid to rest. Note that in this typical case the choice of the exemplary design reflected the privilege granted the specific code defining for it, i.e., designating objects as "safe" or "unsafe." The high wheelers could only have won out by a similar privileging of "fast" and "slow."



Because technologies have such vast social implications, technical designs are often involved in disputes between ideological visions. The outcome of these disputes, a hegemonic order of some sort, brings technology into conformity with the dominant social forces, insuring the "isomorphism, the formal congruence between the technical logics of the apparatus and the social logics within which it is diffused" (Bidou, et al., 1988: 71). These hermeneutic congruencies offer a way to explain the impact of the larger sociocultural environment on the mechanisms of closure, a still relatively undeveloped field of technology studies.

### *Kuhnian Perspectives on Technical Change*

This analysis leads to an obvious question: if all this is true, why aren't we more aware of the public interventions that have shaped technology in the past? Why does it appear apolitical? It is the very success of these interventions that gives rise to this illusion. Success means that technical regimes change to reflect interests excluded at earlier stages in the design process. But the eventual internalization of these interests in design masks their source in public protest. The waves close over forgotten struggles and the technologists return to the comforting belief in their own autonomy which seems to be verified by the conditions of everyday technical work.

The notion of the "neutrality" of technology is a standard defensive reaction on the part of professions and organizations confronted by public protest and attempting to protect their autonomy. But in reality technical professions are never autonomous; in defending their traditions, they actually defend the outcomes of earlier controversies rather than a supposedly pure technical rationality. Informal public intervention is thus already an implicit factor in design whatever technologists and managers may believe.

Lay initiatives usually influence technical rationality without destroying it. In fact, public intervention may actually improve technology by addressing problems ignored by vested interests entrenched in the design process. If the technical professions can be described as autonomous, it is not because they are truly independent of politics but rather because they usually succeed in translating political demands into technically rational terms.

With some modifications, Kuhn's famous distinction between revolutionary and normal science can be reformulated to explain these aspects of the design process (Kuhn, 1962). The alternation of professional and public dominance in technical fields is one of several patterns that correspond roughly to the distinction between normal and revolutionary scientific change. There is, however, a significant difference between science and technology. Natural science eventually becomes far more independent of public opinion than technology. As a result, democratic interventions into scientific change are unusual, and revolutions explode around tensions within the disciplines. Of course even mature science is responsive to politics and culture, but their influence is usually felt indirectly through administrative decisions and changes in education. By contrast, ordinary people are constantly involved in technical activity, the more so as technology advances. It is true that they may be objects rather than subjects of the technologies that affect them, but in any case their closeness offers them a unique vantage point. Situated knowledges arising from that vantage point can become the basis for public interventions even in a mature technological system.

These situated knowledges are usually viewed with skepticism by experts guided by the pursuit of efficiency within the framework of the established technical codes. But in Kuhnian terms, efficiency only applies within a paradigm; it cannot judge between paradigms. To the extent that technical cultures are based on efficiency, they constitute the equivalent of Kuhn's normal science and as such they lack the categories with which to comprehend the paradigmatic changes that will transform them in the course of events. And since democratic interventions are often responsible for such changes, they too remain opaque to the dominant technical culture.

### *Reflexive Design*

The subordination of technology to society is not merely a matter of assigning functions to devices, a self-evident form of dependency. It goes far beyond that to affect the very definition of the functions that ought to be fulfilled, and the quality of the environment associated with the devices that fulfill them, both in production and use. But if that is the case, wouldn't technologists themselves benefit from bringing these issues to the surface in their work? A reflexive design process could take into account the social dimensions of technology at the start instead of waiting to be enlightened by public turmoil or sociological research.



No doubt there are many undocumented cases of reflexive design often stimulated by marketing considerations. I am aware of its growing importance through experience in the field of computer mediated communications. Different types of interface reflect different conceptions of the virtual world in which users must function as they interact online. At first interface designers sought universal solutions to the problems of online communications, but as time went on they began to adjust interfaces to specific group and task requirements. Thus was born the fields of "groupware," and "computer supported cooperative work" (CSCW). From 1984 to 1987, I was personally involved in studying groupware on a series of grants from the US Department of Education, the French Telecom, and the Digital Equipment Corporation (DEC). The aim of the research was to find a meta-design to guide the design of online environments for different types of social groups.

DEC got involved in connection with its networking business. The company recognized that in hooking up computers it was also linking their users in new patterns of interaction and collaboration that would require appropriate software support. We called this the "Social Factors" project. In contrast with human factors, i.e. the adaptation of technology to generic constraints, social factors would adapt computer-created social environments to group needs (Feenberg, 1986b; Feenberg, 1993).

But of course, the reification of a certain conception of group needs in software risks fixing patterns of behavior and authority that might be more easily contested or subverted in less structured face-to-face settings. Thus social factors quickly lead to political factors. This is the burden of Lucy Suchman's piquantly entitled article "Do Categories Have Politics?" (Suchman, 1994). In this article Suchman, who works with software designers at Xerox PARC, developed a political critique of the authoritarian implications of a specific type of CSCW software design.

Examples like this give a hint of the deeper significance of the new theories of technology. The issue is not simply "society's responsibility" for controlling technology, but extends to a reflexive transformation of technical disciplines themselves as the design process becomes socially conscious.

## PROGRESS AND RATIONALITY

### *The Tradeoff Model*

The anti-deterministic arguments of the previous sections of this chapter undermine one basis of the technical professions' claims to autonomy. If they have succeeded in incorporating public concerns in the past, why reject participation on principle today? However, even if the democratic position is granted this much, it is still possible to argue that participation has unreasonable costs. Thus the autonomy thesis still has another leg to stand on. This is the notion that technical rationality can supply the most efficient solution to economic problems when it suffers the least interference. On this basis one might argue that there is an inevitable tradeoff between ideology and technology.

This discussion takes us back over the ground covered in the chapters of Part I. The claims of technical purity were denied most vigorously by anti-technocratic movements such as the May Events that challenged the direction of progress. And the environmental debate turns ultimately on whether environmental goals are compatible with technological advance. Is a democratic alternative to technocracy conceivable? Can a technological society pursue environmental goals without sacrificing prosperity? Many would answer these questions in the negative, claiming that public involvement in technology risks slowing progress to a halt, that democratization and environmental reform are tantamount to Luddite reaction. In this section I will address this objection through an analysis of the limits of technical rationality in social policy.

Let me begin by acknowledging that public fear of technology sometimes results in costly changes or even abandonment of controversial innovations. And of course there is the famous NIMBY ("not in my back yard") syndrome that has greeted nuclear power, toxic waste incinerators, genetic engineering facilities, and other harbingers of a future lived on a higher plane of anxiety.

I call the public's response to new and imponderable risks it is not equipped to evaluate "rational dread." Childhood dread of the monster under the bed can usually be stilled by more information—a simple glance may suffice. But the dread of modern technologies such as atomic energy resists informational strategies. On the contrary, often more information leads to still greater concern. To make matters worse, the hope that expert advice could unburden the public has long since been disappointed as general skepticism overtakes the authority of knowledge. The problem is occasionally resolved by forcing a return to an already accepted level of risk rather than achieving habituation to the higher level involved in new technologies.

The American nuclear power industry has indeed been the victim of just such a response (Morone and Woodhouse, 1989). The significance of this case cannot be overestimated: the nuclear industry was one of the



major technological projects of modern times. Nuclear power promised to free industrial society from dependency on the fragile bottleneck of fossil fuels. But the industry became fixated on unsafe designs in the 1960s and was unable to adapt to the standards of the 1970s and 1980s. In the head on confrontation with public opinion that followed, technology lost, at least in the US. Today conversion initiatives multiply as the owners of old nuclear plants switch back to fossil fuels.

What is the moral of this story? One can conclude with bitter irony that technology is in fact democratically controlled because "the very irrationality that has come to dominate the nuclear debate confirms that the public will is still what counts" (Florman, 1981: 69). But it is a good question where the "irrationality" lay, in the government and utility industries which pushed for impracticable goals or in the public which called them to account out of unverified fears. Clearly, we would be much better off if the many billions of research dollars spent to develop nuclear power had been employed in other ventures, for example, in the fields of solar energy and energy storage.[5]

In any case, this example is not typical. Fear usually does not kill new technology; for the most part, it simply changes the regulatory environment and the orientation of development. Automotive safety and emissions is a good example. Regulation gradually effected changes that were well within the technical capabilities of manufacturers. The results are much safer and less polluting vehicles, not the disaster foreseen by the foes of government "interference."

These issues appear with particular force in the environmental movement. Arguably, this is the single most important domain of democratic intervention into technology. Environmentalists want to reduce harmful and costly side effects of technology to protect nature and human health. This program can be implemented in different ways. As Commoner has argued, in a capitalist society there is a tendency to deflect criticism from technological processes to products and people, from a priori prevention to a posteriori cleanup. These preferred strategies are generally costly and reduce efficiency, with unfortunate political consequences.

Restoring the environment after it has been damaged is a form of collective consumption financed by taxes or higher prices. Because this approach to environmentalism dominates public awareness, it is

[5] For a sensible approach to the problem of the rationality of risk assessment, see Schrader-Frechette (1991).

generally perceived as a cost involving tradeoffs, and not as a rationalization with long-term benefits. But in a modern society, obsessed by economic well-being, that perception is damning. Economists and businessmen are fond of explaining the price we must pay in inflation and unemployment for worshipping at Nature's shrine instead of Mammon's. Poverty awaits those who will not adjust their social and political expectations to technological imperatives.

This tradeoff model has environmentalists grasping at straws for a strategy. As we saw in the previous chapter, Ehrlich held out the pious hope that people would turn from material to spiritual values in the face of the mounting problems of industrial society. Heilbroner expected enlightened dictators to bite the bullet of technological reform even if a greedy populace shirked its duty. It is difficult to decide which of these solutions is more improbable, but both are incompatible with basic democratic values.

The tradeoff model confronts us with dilemmas—environmentally sound technology vs. prosperity, workers' control vs. productivity, etc.—where what we need are syntheses. Unless the problems of modern industrialism can be solved in ways that both enhance public welfare and win public support, there is little reason for hope.

But how can technological reform be reconciled with prosperity when it places a variety of new limits on the economy? The child labor case shows how apparent dilemmas arise on the boundaries of cultural change, specifically where major technological regimes are in transition. In such situations, social groups excluded from the original design network articulate their unrepresented interests politically. New values the outsiders believe would enhance their welfare appear as mere ideology to insiders who are adequately represented by the existing designs.

This is a difference of perspective, not of nature. Yet the illusion of essential conflict is renewed whenever social changes affect technology. At first, satisfying the demands of new groups after the fact has visible costs and, if it is done clumsily, will indeed reduce efficiency until better designs are found. But usually better designs can be found and apparent barriers to growth dissolve in the face of technological change.

This situation indicates the essential difference between economic exchange and technique. Exchange is all about tradeoffs: more of A means less of B. But the aim of technical advance is precisely to avoid such dilemmas by devising what the French philosopher of technology, Gilbert Simondon, called "concrete" designs that optimize several variables at once. A single cleverly conceived mechanism then corresponds to many different social demands, one structure to many functions. As I will explain in the next chapter, design is not a zero-sum economic game but an ambivalent cultural process that serves a multiplicity of values and social groups without necessarily sacrificing efficiency.



### *Regulation of Technology*

That these conflicts over social control of risk are not new can be seen from the interesting case of the "bursting boilers" (Burke, 1972). Steamboat boilers were the first technology the US Government subjected to safety regulation. Over 5000 people were killed or injured in hundreds of steamboat explosions from 1816, when regulation was first proposed, to 1852, when it was actually implemented. Is this many casualties or few? Consumers evidently were not too alarmed to continue traveling by riverboat in ever increasing numbers. Understandably, ship owners interpreted this as a vote of confidence and protested the excessive cost of safer designs. Yet politicians also won votes demanding safety.

The accident rate fell dramatically once technical improvements were mandated. Legislation would hardly have been necessary to achieve this had these improvements been technically determined. But in fact boiler design was relative to a social judgment about safety. That judgment could have been made on market grounds, as the shippers wished, or politically, with differing results. In either case, those results *constitute* a proper boiler. What a boiler "is" was thus defined through a long process of political struggle culminating finally in uniform codes issued by the American Society of Mechanical Engineers.

This example shows how the technical code responds to the changing cultural horizon of the society. Quite down-to-earth technical parameters such as the choice and processing of materials are *socially* specified by the code. The illusion of technical necessity arises from the fact that the code is thus literally "cast in iron," (at least in the case of boilers.)

Conservative anti-regulatory social philosophies are based on this illusion. They forget that the design process always already incorporates standards of safety and environmental compatibility; similarly, all technologies support some basic level of user or worker initiative and skill. A properly made technical object simply *must* meet these standards to be recognized as such. Conformity is no ideological extravagance but an intrinsic production cost. Raising the standards means altering the definition of the object, not paying a price for an alternative good or value as the tradeoff model holds.

### *The Fetishism of Efficiency*

But what of the much discussed cost/benefit ratio of design changes such as those mandated by environmental or other similar legislation? These calculations have some application to transitional situations, before technical advances responding to new demands fundamentally alter the terms of the problem. But it is important not to overestimate their scientific value simply because they are expressed in numbers. All too often, the results depend on economists' very rough estimates of the monetary value of such things as a day of trout fishing or an asthma attack.[6] If made without prejudice, these estimates may well help to prioritize policy alternatives, but one cannot legitimately generalize from such pragmatic applications to a universal theory of the costs of regulation.

Such fetishism of efficiency ignores our ordinary understanding of the concept which is primarily of relevance to social philosophy. In that everyday sense, efficiency concerns those values with which economic actors are routinely concerned. The plumber may compare plastic to copper pipe as to their efficiency; he may even consider septic tanks vs. sewer hookups. But he is not expected to calculate the value of the night soil modern plumbing wastes. Such unproblematic aspects of technology can be safely ignored.[7]

In theory one can decompose any technical object and account for each of its elements in terms of the costs it imposes and the goals it meets, whether it be safety, speed, reliability, etc., but in practice no one is interested in opening the "black box" to see what is inside. For example, once the boiler code is established, such things as the thickness of a wall or the design of a safety valve appear as essential to the object. The cost of these features is not broken out as the specific "price" of safety and compared unfavorably with a more "efficient" but less secure design. Violating the code in order to lower costs is a crime, not a tradeoff.

Design is only controversial while it is in flux. Resolved conflicts over technology are quickly forgotten. Their outcomes, a welter of taken-for-granted technical and legal standards, are embodied in a stable code, and form the background against which economic actors manipulate the unstable portions of the environment in the pursuit of efficiency. The code itself is not normally varied in real world economic calculations, and as further advance occurs on the basis of it, movement backward no longer seems technically feasible.

Anticipating the stabilization of a new code, one can often ignore contemporary arguments that will soon be silenced by the emergence of a new horizon of efficiency calculations. This is what happened with boiler design and child labor; presumably, current debates on the environment will have a similar history and we will someday mock those who object to cleaner air and water as a "false principle of humanity" that violates technological imperatives.

There is a larger issue here. Non-economic values intersect the economy in the technical code. The examples we are dealing with illustrate this point clearly. The legal standards that regulate workers' economic activity have a significant impact on every aspect of their lives. In the child labor case, regulation widened educational opportunities with consequences that are not primarily economic in character. In the riverboat case, the choice of high levels of security was no tradeoff of one good for another, but a non-economic decision about the value of human life and the responsibilities of government.

Technology is thus not merely a means to an end; technical design standards define major portions of the social environment, such as urban and built spaces, workplaces, medical activities and expectations, life patterns, and so on. The economic significance of technical change often pales beside its wider human implications in framing a way of life. In such cases, regulation defines the cultural framework *of* the economy; it is not an act *in* the economy.

### *The Concept of Potentiality*

The false dilemmas of technical politics arise from a peculiarity of change in the technical sphere. Technical resources can be configured in many different patterns. Any given configuration realizes a certain fraction of the well-being potentially available at the achieved technical level. Unrealized technical potential stands as a measure of the existing system. Where the contrast between what is and what might be becomes a political issue, technical resources are reconfigured in response to public pressure.

[6] There are actually fairly sophisticated ways of estimating the value of a day of trout fishing. But what is the "cost" of an asthma attack? I recall once reading to my two asthmatic children the news summary of an economist's argument against revising the Clean Air Act. On hearing that the economist had valued asthma attacks at an average of $25 each, my children were outraged. But would it really improve matters much to multiply the numbers by two, five, or ten? The inherent flaws of this method of evaluating regulations far outweigh the advantages where significant health issues are concerned.

[7] This limitation is related to the concept of satisficing. See Elster (1983:138ff).

Looking back, the new configuration may seem obvious, but looking forward it is often very difficult to imagine radical technical solutions to contemporary problems. Worse still, without a clear idea of a solution, it is difficult even to formulate the problems clearly in their technical aspect. Thus often only after innovations have been introduced does it become entirely clear to what demand they respond.

Not only is it difficult to anticipate future technical arrangements, it is all too easy to think up utopias that cannot be realized under the existing ones. Thoroughgoing social changes are often inspired by such large ideological visions. In such cases, the long-term success of the new vision depends on its ability to deliver a better life over an extended period. That in turn depends on the technical changes necessary for its realization. Once success has been achieved, it is possible to look back and argue that the older way of life obstructed progress. In anticipation, theory may situate itself imaginatively on the boundary of the new civilizational configuration that will give a concrete content to its speculations, judging this society from the standpoint of a possible successor. However, so long as its hopes remain contingent for their realization on still unimagined technical advances, they can only take an ethical or ideological form. Their concrete formulation depends ultimately on the advances that will someday realize them by locking in the sort of irreversible sequence we call progress. As progress unfolds on the basis of the constrained choices that have shaped technology in the past, lines of development emerge with a clear direction. What were once values posited in the struggle for the future, become facts inherited from the past as the technical and institutional premises of further advance.

In economics the failure to actualize the full potential of a resource is called "suboptimization." Where suboptimizations are rooted in the technical code, we are dealing not with a specific or local failure but with the generalized wastefulness of a whole technological system. In economic terms, unrealized civilizational potentialities appear as systematic underemployment of major resources due to the restrictions the dominant economic culture places on technical and human development. A new culture is needed to shift patterns of investment and consumption and to open up the imagination to technical advances that transform the horizon of economic action.

The speculative claims of morality become ordinary facts of life through such civilizational advances. The child labor example illustrates these points clearly. Reforms based on ethical demands led to social changes so profound that eventually those demands became self-evident



facts of life. At the time, businessmen worried about the economic costs of the reforms, but today these costs seem trivial, even irrelevant, in the light of the enormous human gain that results from the modern practices of child rearing and education. Of course time is of the essence in such cases. The point of view of contemporaries is not arbitrary, just subject to radical reinterpretation in a wider historical context. Something similar seems to be occurring today in the movements for environmental reform and for the equality of women and racial minorities.

Where the struggle for new ideals succeeds in restructuring society around a new culture, it will not be perceived as trading off wealth against morality, but as realizing the economic potentialities associated with its ethical claims. The dilemma of virtue and prosperity is not absolute, but can be mediated in the course of technological development. This was Commoner's position as we saw in the last chapter. He resisted the suggestion that environmental protection is incompatible with prosperity, and attempted to redefine social wealth in more inclusive terms. To some extent this redefinition has actually taken hold. As it sinks down into the structure of technology itself, through advances that adapt technical systems to the natural environment, it will become "obvious" that environmentalism represents progress.

Because economic culture is not fixed once and for all, and because a population's socially relative goals may be served by a variety of technological means, it is possible to link ideals and interests in a progressive process of technical change. In that process potentialities that appear at first in ethical or ideological form are eventually realized in an effective consciousness of self-interest. This link makes possible a radical democratic politics of technology.