Between Reason and Experience

Essays in Technology and Modernity

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1 Democratic Rationalization: Technology, Power, and Freedom

The Limits of Democratic Theory

Technology is one of the major sources of public power in modern societies. So far as decisions affecting our daily lives are concerned, political democracy is largely overshadowed by the enormous power wielded by the masters of technical systems: corporate and military leaders and professional associations of groups such as physicians and engineers. They have far more to do with control over patterns of urban growth, the design of dwellings and transportation systems, the selection of innovations, and our experience as employees, patients, and consumers than do all the governmental institutions of our society put together.

Marx saw this situation coming in the middle of the nineteenth century. He argued that traditional democratic theory erred in treating the economy as an extrapolitical domain ruled by natural laws such as the law of supply and demand. He claimed that we will remain disenfranchised and alienated so long as we have no say in industrial decision making. Democracy must be extended from the political domain into the world of work. This is the underlying demand behind the idea of socialism.

Modern societies have been challenged by this demand for over a century. Democratic political theory offers no persuasive reason of principle to reject it. Indeed, many democratic theorists endorse it (Cunningham 1987). What is more, in a number of countries, socialist parliamentary victories or revolutions have brought to power parties dedicated to achieving it. Yet today we do not appear to be much closer to democratizing industrialism than in Marx's time.

This state of affairs is usually explained in one of the following two ways.

Technology is determining. On the one hand, common sense argues that modern technology is incompatible with workplace democracy. Democratic theory cannot reasonably press for reforms that would destroy the economic foundations of society. For evidence, consider the Soviet case: although they were socialists, Lenin and his successors did not democratize industry, and even at its most liberal, the democratization of Soviet society extended only to the factory gate. Today in the ex-Soviet Union, everyone still agrees on the need for authoritarian industrial management.

Technology is neutral. On the other hand, a minority of radical theorists claims that technology is not responsible for the concentration of industrial power. That is a political matter, due to the victory of capitalist and communist elites in struggles with the underlying population. No doubt modern technology lends itself to authoritarian administration, but in a different social context it could just as well be operated democratically.

In what follows, I will argue for a qualified version of this second position, somewhat different from both the usual Marxist and radical democratic formulations. The qualification concerns the role of technology, which I see as *neither* determining nor as neutral. I will argue that modern forms of hegemony are based on a specific type of technical mediation of a variety of social activities, whether it be production or medicine, education or the military, and that, consequently, democratization requires radical technical as well as political change.

This is a controversial position. Political theorists usually limit the proper application of the concept of democracy to the state. By contrast, I believe that unless democracy can be extended beyond its traditional bounds into the technically mediated domains of social life, its use value will continue to decline, participation will wither, and the institutions we identify with a free society will gradually disappear.

Let me turn now to the background of my argument. I will begin by presenting an overview of various theories that claim that technologically advanced societies require authoritarian hierarchy. These theories presuppose a form of technological determinism that is refuted by historical and sociological arguments I will briefly summarize. I will then present a sketch of a nondeterministic theory of modern society I call "critical theory of technology." This alternative approach emphasizes the impact of contextual aspects of technology on design ignored by the dominant

view. I will argue that technology is not just the rational control of nature; both its development and impact are intrinsically social. I will then show that this view undermines the customary reliance on efficiency as an explanation of technological development in both optimistic and dystopian accounts of modernity. This conclusion, in turn, opens broad possibilities of change foreclosed by the usual understanding of technology. That argument is developed further in the following chapters.

Dystopian Modernity

Max Weber's famous theory of rationalization is the original argument against industrial democracy. The title of this chapter implies a provocative reversal of Weber's conclusions. He defined rationalization as 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). "Democratic" rationalization is thus a contradiction in terms.

Once traditionalist struggle against rationalization has been defeated, further resistance in a Weberian universe can only affirm an irrational life force against routine and drab predictability. This is not a democratic program but a romantic anti-dystopian one, the sort of thing that is already foreshadowed in Dostoyevsky's *Notes from Underground* and various back-to-nature ideologies.

My title is meant to reject the dichotomy between rational hierarchy and irrational protest implicit in Weber's position. If authoritarian social hierarchy is truly a contingent dimension of technical progress, as I believe, and not a technical necessity, then there must be an alternative rationalization of society that democratizes rather than centralizes control. We need not go underground or native to preserve threatened values such as freedom and individuality.

But the most powerful critiques of modern technological society follow directly in Weber's footsteps in rejecting this possibility. I am thinking of Heidegger's formulation of "the question of technology" and Ellul's theory of "the technical phenomenon" (Heidegger 1977; Ellul 1964). According to these theories, we have become little more than objects of technique, incorporated into the mechanism we have created. The only hope is a vaguely evoked spiritual renewal that is too abstract to inform a new technical practice.

These are interesting theories, important for their contribution to opening a space of reflection on modern technology. I will return to Heidegger's argument in the conclusion to this chapter and in the final part of this book. But first, to advance my own argument, I will concentrate on the principal flaw of dystopianism, the identification of technology in general with the specific technologies that have developed in the last two centuries in the West. These are technologies of conquest that pretend to an unprecedented autonomy; their social sources and impacts are hidden. I will argue that this type of technology is a particular feature of our society and not a universal dimension of modernity as such.

Technological Determinism

Determinism rests on the assumption 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. It would seem that society's fate is at least partially dependent on a nonsocial factor that influences it without suffering a reciprocal impact. This is what is meant by "technological determinism." A deterministic view of technology is commonplace in business and government, where it is often assumed that technical progress is an exogenous force influencing society rather than an expression of changes in culture and values.

Dystopian visions of modernity are also deterministic. If we want to affirm the democratic potentialities of modern industrialism, we will therefore have to challenge their deterministic premises, the thesis of unilinear progress, and the thesis of determination by the base.

1. According to determinism, technical progress follows a unilinear course, a fixed track, from less to more advanced configurations. Although this seems obvious from a backward glance at the development 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. 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 now part of the common sense of the social sciences (Miller 1984, 188–195). Following and in the next chapter, I will discuss one of its implications in detail: the supposed "trade-off" between prosperity and environmental values.

These two theses of technological determinism present decontextualized, self-generating technology as the foundation of modern society. 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. Developing societies should 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 reprint, 13).

Constructivism

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

Recent constructivist sociology of technology grows out of social studies of science (Bloor 1991, 175–179; Latour 1987). I employ the term "constructivism" loosely to refer to the theory of large-scale technical systems, social constructivism, and actor-network theory. They have in common an emphasis on the social contingency of technical development. They challenge the traditional view of the autonomy of technology and study it much as one might an institution or a law. The specifics of these methodologies are not relevant here, but this general approach lends support to the critical theory of technology.

Constructivism challenges our tendency to exempt scientific theories from the sort of sociological examination to which we submit nonscientific beliefs. It affirms the "principle of symmetry," according to which all contending beliefs are subject to the same type of social explanation regardless of their truth or falsity. A similar approach to technology rejects the usual assumption that technologies succeed on purely functional grounds.

Constructivism argues that theories and technologies are underdetermined by scientific and technical criteria. Concretely, this means two things: first, there is generally a surplus of workable solutions to any given problem, with social actors making the final choice among several viable options; and second, the problem definition often changes in the course of solution.

Trevor Pinch and Wiebe Bijker illustrate these points with the example of the bicycle. In the late nineteenth century, before the present form of the bicycle was fixed, design was pulled in several different directions. Some customers perceived bicycling as a competitive sport, while others had an essentially utilitarian interest in transportation. Designs corresponding to the first definition had high front wheels that were rejected as unsafe by the second type of rider. They preferred the "safety" with two equal-sized low wheels. With the introduction of inflatable tires the low wheelers won out, and the entire later history of the bicycle down to the present day stems from that line of technical development. Technology is not determining in this example; on the contrary, the "different interpretations by social groups of the content of artifacts lead via different chains of problems and solutions to different further developments" (Pinch and Bijker 1989, 42).

Pinch and Bijker call this variability of goals the "interpretative flexibility" of technologies. What a technology *is* depends on what it is *for*, and that is often in dispute. The flexibility of technologies is greatest at the outset and diminishes as the competition between alternatives is sorted out. Finally, closure is achieved in the consolidation of a standard design capable of prevailing for an extended period. This is what happened to the bicycle, the automobile, and most of the familiar technologies that surround us.

In the case of the bicycle, the "safety" design won out, and it benefited from all the later advances. 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 represents a possible alternative path of bicycle development that addressed different problems at the origin. The defeated alternative was left frozen in time like a dinosaur fossil and so appears obviously inferior today in a typical illusion of progress.

Determinism is a species of Whig history that tells the story as though the end was inevitable by projecting the abstract technical logic of the finished object back into the past as the *telos* of development. That approach confuses our understanding of the past and stifles 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.[1]

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 attitudes in the struggle over the length of the workday and child labor in mid-nineteenth-century England. The debate on the Factory Bill of 1844 was entirely structured around the opposition of technological imperatives and ideology. Lord Ashley, the chief advocate of regulation, protested that "The tendency of the various improvements in machinery is to supersede the employment of adult males, and substitute in its place, the labour of children and females. What will be the effect on future generations, if their tender frames be subjected, without limitation or control, to such destructive agencies?"[2]

He went on to deplore the decline of the family consequent upon the employment of women, which "disturbs the order of nature" and deprives children of proper upbringing. "It matters not whether it be prince or peasant, all that is best, all that is lasting in the character of a man, he has learnt at his mother's knees." Lord Ashley was outraged to find that "females not only perform the labour, but occupy the places of men; they

are forming various clubs and associations, and gradually acquiring all those privileges which are held to be the proper portion of the male sex. . . . they meet together to drink, sing, and smoke; they use, it is stated, the lowest, most brutal, and most disgusting language imaginable . . ."

Proposals to abolish child labor met with consternation on the part of factory owners, who regarded the little worker as an "imperative" of the technologies created to employ him. They denounced the "inefficiency" of using full-grown workers to accomplish tasks done as well or better by children, and they predicted all the usual catastrophic economic consequences—increased poverty, unemployment, loss of international competitiveness—from the substitution of more costly adult labor. Their eloquent representative, Sir J. Graham, therefore urged caution: "We have arrived at a state of society when without commerce and manufactures this great community cannot be maintained. Let us, as far as we can, mitigate the evils arising out of this highly artificial state of society; but let us take care to adopt no step that may be fatal to commerce and manufactures."

He further explained that a reduction in the workday for women and children would conflict with the depreciation cycle of machinery and lead to lower wages and trade problems. He concluded that "in the close race of competition which our manufacturers are now running with foreign competitors . . . such a step would be fatal. . . ." Regulation, he and his fellows maintained in words that echo still, is based on a "false principle of humanity, which in the end is certain to defeat itself." One might almost believe that Ludd had risen again in the person of Lord Ashley: the issue is not really the regulation of work, "but it is in principle an argument to get rid of the whole system of factory labour." Similar protestations are heard today on behalf of industries threatened with what they call environmental "Luddism."

Yet what actually happened once the regulators imposed limitations on the workday and expelled children from the factory? Did the violated imperatives of technology come back to haunt them? 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. A vast historical process unfolded, partly stimulated by the ideological debate over how children should be

raised and partly economic. It led eventually to the current situation in which nobody dreams of returning to cheap child labor in order to cut costs, at least not in the developed countries.

This example shows the tremendous flexibility of the technical system. It is not rigidly constraining but on the contrary can adapt to a variety of social demands. This conclusion should not be surprising, given the responsiveness of technology to social redefinition discussed previously. In sum, 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 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. In the second place, technological development is not determining for society but is overdetermined by 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 "enlarges the field of the possible."[3] If technology has many unexplored potentialities, no technological imperatives dictate the current social hierarchy. Rather, technology is a scene of social struggle, a "parliament of things," on which civilizational alternatives contend (Latour 1993).

Interpreting Technology

In the next sections of this chapter, I would like to present several major themes of a nondeterminist approach to technology. The picture sketched so far implies a significant change in definition. Technology can no longer be considered as a collection of devices nor, more generally, as the sum of rational means. These are tendentious definitions that beg the question of technology's social significance and involvements.

Insofar as it is social, technology ought to be subject to interpretation like any other cultural artifact, but it is generally excluded from 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. Technological determinism draws its force from this attitude. If one ignores most of the connections between technology and society, it is no wonder that technology then appears to be self-generating.

Technical objects have two hermeneutic dimensions that I call their *social meaning* and their *cultural horizon*.[4] The role of social meaning is clear in the bicycle case. We have seen that the design of the bicycle was decided by a contest of interpretations: Was it to be a sportsman's toy or a means of transportation? Design features such as wheel size signified it as one or another type of object while also suiting it to its function.

It might be objected that this is merely an initial disagreement over functions with no hermeneutic significance. Once the object is stabilized, the engineer has the last word on its nature, and the humanist interpreter is out of luck. This is the view of most engineers and managers; they readily grasp the concept of "function," but they have no use for "meaning."

In fact the dichotomy of function and meaning is a product of modern technical cultures, which are themselves rooted in the structure of the modern economy. The concept of "function" strips technology bare of social contexts, focusing engineers and managers on just what they need to know to do their job. A fuller picture is conveyed, however, by studying the social role of technical objects and the lifestyles they make possible. That picture places the abstract notion of "function" in its concrete social context. It makes technology's contextual causes and consequences visible rather than obscuring them behind an impoverished functionalism.[5]

The functionalist point of view yields a decontextualized temporal cross-section in the life of the object. As we have seen, determinism 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 unpredictable attitudes crystallize around technical objects and influence later design changes. The engineer may think these are extrinsic to the device he or she is working on, but they are its very substance as a historically evolving phenomenon.

These facts are recognized to a certain extent in the technical fields themselves. With computers, we have a contemporary version of the dilemma of the bicycle discussed earlier. Progress of a generalized sort in speed, power, and memory goes on apace while corporate planners struggle with the question of what it is all for. Technical development does not

point definitively toward any particular path. Instead, it opens branches, and the final determination of the "right" branch is not within the competence of engineering because it is simply not inscribed in the nature of the technology.

I have studied a particularly clear example of the complexity of the relation between the technical function and meaning of the computer in the case of French videotex.[6] Called "Teletel," this system was designed to bring France into the Information Age by giving telephone subscribers access to databases through a standard dumb terminal. Fearing that consumers would reject anything resembling office equipment, the telephone company attempted to redefine the computer's social image; it was no longer to appear as a filing and calculating device for professionals but was to become a public informational network.

The telephone company designed a new type of terminal, the Minitel, to look and feel like an adjunct to the domestic telephone. The telephonic disguise suggested to some users that they ought to be able to talk to each other on the network. Soon the Minitel underwent a further redefinition at the hands of these users, many of whom employed it primarily for anonymous online chatting with other users in the search for amusement, companionship, and sex.

Thus the design of the Minitel invited communications applications that the company's engineers had not intended when they set about improving the flow of information in French society. Those applications, in turn, connoted the Minitel as a means of personal encounter, the very opposite of the rationalistic project for which it was originally created. The "cold" computer became a "hot" new medium.

At issue in the transformation was not only the computer's narrowly conceived technical function but also the very nature of society it makes possible. Does networking open the doors to the Information Age, where, as rational consumers hungry for data, we pursue strategies of optimization? Or is it a postmodern technology that emerges from the breakdown of institutional and sentimental stability? In this case technology is not merely the servant of some predefined social purpose; it is an environment within which a way of life is elaborated.

In sum, differences in the way social groups interpret and use technical objects are not merely extrinsic but make a difference in the nature of the objects themselves. *What* the object *is* for the groups that ultimately decide

its fate determines what it *becomes* as it is redesigned and improved over time. If this is true, then we can understand technological development only by studying its meaning for the various groups that influence it.

Technological Hegemony

In addition to the assumptions about individual technical objects we have been discussing so far, meanings belonging to the cultural horizon of society also shape technologies. This second hermeneutic dimension of technology is the basis of modern forms of social hegemony; it is particularly relevant to our original question concerning the inevitability of hierarchy in technological society.

As I will use the term, hegemony is a form of 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 that 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.[7] 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. Rationalization is our modern horizon, and technological design is the key to its effectiveness as the basis of modern hegemonies.

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 nineteenth-century production technology. Such assumptions seem so natural and obvious they often lie below the threshold of conscious awareness.

This is the point of Herbert Marcuse's important critique of Max Weber's theory of rationalization (Marcuse 1968). Marcuse shows that Weber confounds the control of labor by management with the control of nature by technology. The search for control of nature is generic, but management arises only against a specific social background, the capitalist system. Workers have no immediate interest in output in this system since their

wage is not essentially linked to the income of the firm. Control of human beings becomes all-important in this context. Another way to put it would be to say that top down management is "rational" under the horizon of capitalism, but Weber left off the qualifying phrase.

Through mechanization, some of the control functions are eventually transferred from human overseers and parcelized work practices to machines. Machine design is thus socially relative in a way that Weber never recognized, and the "technological rationality" it embodies is not universal but particular to capitalism. In fact, it is the horizon of all the existing industrial societies, communist as well as capitalist, insofar as they are managed from above.

If Marcuse is right, it ought to be possible to trace the impress of class relations in the very design of production technology, as has indeed been shown by such Marxist students of the labor process as Harry Braverman and David Noble (Braverman 1974; Noble 1984). The assembly line offers a particularly clear instance because its design achieves traditional management goals, such as deskilling and pacing work. Its technologically enforced labor discipline increases productivity and profits by increasing control. However, the assembly line appears as technical progress only in a specific social context. It would not be perceived as an advance in an economy based on workers' cooperatives in which labor discipline was largely self-imposed rather than imposed from above. In such a society, a different technological rationality would dictate different ways of increasing productivity.

This example shows that technological rationality is not merely a belief, an ideology, but is effectively incorporated into the structure of machines. Machine design mirrors back the social factors operative in the prevailing rationality. The fact that the argument for the social relativity of modern technology originated in a Marxist context has obscured its most radical implications. We are not dealing here with a mere critique of the property system but have extended the critique down into the technical "base," the forces of production. This approach goes well beyond the old economic distinction between capitalism and socialism, market and plan. Instead, one arrives at a very different distinction between societies in which power rests on the technical mediation of social activities and those that democratize technical control and, correspondingly, technological design.

Double Aspect Theory

The argument to this point might be summarized as a claim that social meaning and functional rationality are inextricably intertwined dimensions of technology. They are not ontologically distinct with meaning in the observer's mind and rationality in the technology proper. Rather they are "double aspects" of the same underlying technical object, each aspect revealed by a specific contextualization.[8]

Functional rationality isolates objects from their original context in order to incorporate them into a theoretical system. The institutions that support this procedure, such as laboratories and research and design centers, themselves form a special context with their own practices and links to various social agencies and powers. The notion of "pure" rationality arises when the work of decontextualization is not itself grasped as a social activity reflecting social interests.

Technologies are selected by these interests from among many possible configurations. Guiding the selection process are social codes established by the cultural and political struggles that define the cultural horizon under which the technology will fall. Once introduced, technology offers a material validation of the social order to which it has been preformed. I call this the "bias" of technology: apparently neutral, functional rationality is enlisted in support of a hegemony. The more technology society employs, the more significant is this support.[9]

As Foucault argued in his theory of "power\knowledge," modern forms of oppression are based not so much on false ideologies as on the specific technical "truths" that found and reproduce the dominant hegemony (Foucault 1977). So long as the contingency of the choice of "truth" remains hidden, the deterministic image of a technically justified social order is projected.

The legitimating effectiveness of technology depends on unconsciousness of the cultural horizon under which it was designed. A recontextualizing critique of technology can uncover that horizon, demystify the illusion of technical necessity, and expose the relativity of the prevailing technical choices. A politics of technology can demand changes reflecting the critique.

The possibility of such a politics is rooted in a peculiar feature of the double aspects of technology. Although function and meaning are

analytically distinct aspects of technologies in any temporal cross-section, they interact externally in historical time. They enjoy what might be called a "relationship of double ingression," the data of each invading the other and operating in a paradoxical way on the other's terrain. Everyday experience, the domain of social meaning, is governed by a different logic from the scientific and engineering rationality that presides over the functional logic of technology. Where these contexts are out of alignment, tensions arise that are resolved in the course of history by changes and adjustments in one or both of them.

This is methodologically puzzling but obvious in specific cases. For example, knowledge of risk enters experience as fear or anxiety, that is, an aspect of the meaning of the associated objects. Nuclear power is a case in point. The social meaning of the technology is informed in part by scientific knowledge of risk. But more ancient layers of meaning crystallize around invisible threats and fear of the unknown. Meanwhile, scientists and engineers respond to public perceptions of risk with new designs that promise improved safety. Thus the social meaning of the technology influences the rational specification of the device. In other fields such as computing, new functionalities are routinely introduced in response to changes in meaning.

The Social Relativity of Efficiency

These issues appear with particular force in the environmental movement. Many environmentalists argue for technical changes that would protect nature and in the process improve human life as well. Such changes would enhance efficiency in broad terms by reducing harmful and costly side effects of technology. However, this program is very difficult to implement in a capitalist society. There is a tendency to deflect criticism from technological processes to products and people, from apriori prevention to aposteriori clean-up. These preferred strategies are costly and reduce efficiency in the short run. This situation has political consequences.

Reducing side effects and restoring the environment are forms of collective consumption, financed by taxes or higher prices. These approaches dominate public awareness. This is why environmentalism is generally perceived as a cost involving trade-offs and not as a rationalization increasing overall well-being. But in a society obsessed by private consumption,

that perception is damning. Economists and businesspeople 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 trade-off approach has environmentalists grasping at straws for a strategy. Some hold out the pious hope that people will turn from economic to spiritual values in the face of the mounting problems of industrial society. Others expect enlightened dictators to impose technological reform on an irrational populace. It is difficult to decide which of these solutions is more improbable, but both are incompatible with basic democratic values (Heilbroner 1975).

The trade-off approach confronts us with dilemmas—environmentally sound technology versus prosperity, workers' satisfaction and control versus productivity, and so forth—where what we need are syntheses. Unless the problems of modern industrialism can be solved in ways that both protect nature and win public support, there is little reason to hope that they will ever be solved. 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 the social definition of major technologies is in transition. In such situations, social groups excluded from the original design process 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 major 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 are found, and what appeared to be insuperable obstacles to growth dissolve in the face of technological change.

This situation indicates the essential difference between economic exchange and technique. Exchange is all about trade-offs: more of A means less of B. But the aim of technical advance is precisely to avoid such dilemmas with what Simondon calls "concretizations," elegant designs that

optimize several variables at once. A single cleverly conceived mechanism may correspond to many different social demands, one structure to many functions. 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.[10]

The Technical Code

That these conflicts over social control of technology are not new can be seen from the interesting case of the "bursting boilers" (Burke 1972). Steamboat boilers were the first technology regulated in the United States. In the early nineteenth-century the steamboat was a major form of transportation, similar to the automobile or airlines today. The United States was a big country without paved roads but with many rivers and canals, hence the reliance on steamboats. But steamboats frequently blew up when the boilers weakened with age or were pushed too hard. After several particularly murderous accidents in 1816, the city of Philadelphia consulted with experts on how to design safer boilers. This was the first time an American governmental institution interested itself in the problem. In 1837, at the request of Congress, the Franklin Institute issued a detailed report and recommendations based on rigorous study of boiler construction. Congress was tempted to impose a safe boiler code on the industry, but boilermakers and steamboat owners resisted, and the government hesitated to interfere with private property.

It took from that first inquiry in 1816 until 1852 for Congress to pass effective laws regulating the construction of boilers. In that time five thousand people died in steamboat accidents. Is this many casualties or few? Consumers evidently were not too alarmed to travel on the rivers in ever increasing numbers. Understandably, the ship owners interpreted this as a vote of confidence and protested the excessive cost of safer designs. Yet politicians also won votes by demanding safety.

The accident rate fell dramatically once thicker walls and safety valves were mandated. Legislation would hardly have been necessary to achieve this outcome had it been technically determined. But in fact boiler design was relative to a social judgment about safety. That judgment could have been made on strictly market grounds, as the shippers wished, or politically, with differing implications for technical design. 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 is an example of how technology adapts to social change. What I call the "technical code" of the object mediates the process. That code responds to the cultural horizon of the society at the level of technical design. 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.

The conservative antiregulatory approach is based on an illusion. It forgets 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. A properly made technical object simply *must* meet these standards to be recognized as such. We do not treat conformity as an expensive add-on but regard it as an intrinsic cost. Raising the standards means altering the definition of the object, not paying a price for an alternative good or ideological value, as the trade-off approach holds.

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 technological advances responding to new values fundamentally alter the terms of the problem. But 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. If made without prejudice, these estimates may well help to prioritize policy alternatives. But one cannot legitimately generalize from such policy applications to a universal theory of the costs of regulation.[11]

Such fetishism of efficiency ignores our ordinary understanding of the concept, which alone is relevant to social decision making. In that everyday sense, efficiency concerns the narrow range of issues that economic actors routinely address. Unproblematic aspects of technology are not included. In theory one can decompose any technical object and account for each of its elements in terms of the goals it meets, whether it be safety, speed, reliability, and so forth, 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 version of the technology. Violating the code in order to lower costs is a crime, not a trade-off. And since all further progress takes place on the basis of the new safety standard, soon no one looks back to the good old days of cheaper, insecure designs.

Design standards are controversial only while they are 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 unstabilized aspects of technology in the pursuit of efficiency. The code is not varied in real-world economic calculations but treated as a fixed input.

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, the current debates on environmentalism will have a similar history, and we will someday mock those who object to cleaner air as a "false principle of humanity" that violates technological imperatives.

Noneconomic values intersect the economy in the technical code. The examples we are dealing with illustrate this point clearly. The legal standards that regulate economic activity have a significant impact on every aspect of our lives. In the child labor case, regulation helped to widen educational opportunities with human consequences that are not merely economic in character. In the riverboat case, Americans chose high levels of security, and boiler design came to reflect that choice. Ultimately, this was no trade-off of one good for another but a noneconomic 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 just an act *in* the economy.

Heidegger's "Essence" of Technology

The theory sketched here suggests the possibility of a general reform of technology. But dystopian critics object that the mere fact of pursuing efficiency or technical effectiveness already does inadmissible violence to human beings and nature. Universal functionalization destroys the integrity of all that is. As Heidegger argues, an "objectless" world of mere resources replaces a world of "things" treated with respect for their own sake as the gathering places of our manifold engagements with "Being."[12]

This critique gains force from the actual perils with which modern technology threatens the world today. But my suspicions are aroused by Heidegger's famous contrast between a dam on the Rhine and a Greek chalice. It would be difficult to find a more tendentious comparison. No doubt modern technology is immensely more dangerous than any other. No doubt it invalidates traditional meanings without providing an adequate substitute. And Heidegger is right to argue that means are not truly neutral, that their substantive content affects society independent of the goals they serve. But this content is not *essentially* destructive; rather its significance is a matter of design and social insertion.

However, Heidegger rejects any merely social diagnosis of the ills of technological societies and claims that the source of their problems dates back at least to Plato, that modern societies merely realize a *telos* immanent in Western metaphysics from the beginning. His originality consists in pointing out that the ambition to control being is itself a way of being and hence subordinate at some deeper level to an ontological dispensation beyond human control. But the overall effect of his critique is to condemn human agency, at least in modern times, and to confuse essential differences between types of technological development.

Heidegger and his followers distinguish between the *ontological* problem of technology, which can be addressed only by achieving what they call "a free relation" to technology, and the merely *ontic* solutions proposed by reformers who wish to change technology itself. This distinction may once have seemed more interesting than it does today. In effect, Heidegger is asking for nothing more than a change in attitude toward the selfsame technical world. But that is an idealistic solution in the bad sense and one that a generation of environmental activism decisively refutes.

Confronted with this argument, Heidegger's defenders usually point out that his critique of technology is not concerned merely with attitudes but with the way being "reveals" itself. Roughly translated out of Heidegger's language, this means that the modern world has a technological form in something like the sense in which, for example, the medieval world had a religious form. Form is no mere question of attitude but takes on a material life of its own: power plants are the gothic cathedrals of our time. But this interpretation of Heidegger's thought raises the expectation that he will offer criteria for a reform of technology. For example, his critique of the tendency of modern technology to accumulate and store up nature's powers suggests the superiority of another technology that would not challenge nature in Promethean fashion.

But Heidegger does not pursue this line. Instead, he develops his argument at such a high level of abstraction he literally cannot discriminate between electricity and atom bombs, agricultural techniques and the Holocaust. In a 1949 lecture, he asserted: "Agriculture is now the mechanized food industry, in essence the same as the manufacturing of corpses in gas chambers and extermination camps, the same as the blockade and starvation of nations, the same as the production of hydrogen bombs" (quoted in Rockmore 1992, 241). All are merely different expressions of the identical "enframing" that we are called to transcend through the recovery of a deeper relation to being. And since Heidegger rejects technological regression while leaving no room for reform, it is difficult to see in what that relation would consist beyond a mere change of attitude.

Heidegger cannot take the notion of technological reform seriously because he reifies modern technology as something separate from society, as an inherently contextless force aiming at pure power. If this is the "essence" of technology, reform would be merely extrinsic. But at this point Heidegger's position converges with the very Prometheanism he rejects. Both depend on the narrow definition of technology that, at least since Bacon and Descartes, has emphasized its destiny to control the world to the exclusion of its equally essential contextual embeddedness. This definition reflects the capitalist environment in which modern technology first developed.

The exemplary modern master of technology is the entrepreneur, single-mindedly focused on production and profit. The enterprise is a radically decontextualized platform for action, without the traditional

responsibilities for persons and places that went with technical power in the past. It is the autonomy of the enterprise that makes it possible to distinguish so sharply between intended and unintended consequences, between goals and contextual effects, and to ignore the latter.

The narrow focus of modern technology meets the needs of a particular hegemony; it is not a metaphysical condition. Under that hegemony, technological design is unusually decontextualized and destructive. Not technology but that hegemony is called to account when we point out that today technical means form an increasingly threatening life environment. It is that hegemony, as it is materialized in technology, which must be challenged in the struggle for a better society.

Democratic Rationalization

For generations, faith in progress was supported by two widely held beliefs: that technical necessity dictates the path of development and that the pursuit of efficiency provides a basis for identifying that path. I have argued here that both these beliefs are false and that, furthermore, they are ideologies employed to justify restrictions on opportunities to participate in decision making in industrial society. I conclude that a reform of technological society can support a broader range of values. Democracy is one of these values.

What does it mean to democratize technology? The problem is not primarily one of legal rights but of initiative and participation. Legal forms may eventually routinize claims that are asserted informally at first, but the forms will remain hollow unless they emerge from the experience and needs of individuals resisting a technocratic hegemony.

That resistance takes many forms, from union struggles over health and safety in nuclear power plants to community struggles over toxic waste disposal to political demands for regulation of reproductive technologies. These movements alert us to the need to take technological externalities into account and demand design changes responsive to the enlarged context revealed in that accounting.

Such technological controversies have become an inescapable feature of contemporary political life, laying out the parameters for official "technology assessment" (Cambrosio and Limoges 1991; Callon et al. 2009). They prefigure the creation of a new public sphere embracing the technical

background of social life and a new style of rationalization that internalizes unaccounted costs born by "nature," that is, some-thing or -body exploitable in the pursuit of profit. Here respect for nature is not antagonistic to technology but opens a new path of development.

As these controversies become commonplace, surprising new forms of resistance and new types of demands emerge. The Minitel example is a model of this new situation. In France, the computer was politicized as soon as the government supplied the general public with a highly rationalistic information system. Users "hacked" the network in which they were enrolled and altered its functioning, introducing human communication on a vast scale where only the centralized distribution of data had been planned. The Internet has also given rise to many such innovative public reactions to technology.

Individuals who are incorporated into these new technical networks have learned to resist through the net itself in order to influence the powers that control it. This is not a contest for wealth or administrative power but a struggle to subvert the technical practices, procedures, and designs structuring everyday life.

It is instructive to compare these cases with the movement of AIDS patients for better medical care. Just as a rationalistic conception of the computer tends to occlude its communicative potentialities, so in medicine caring functions have become mere side effects of treatment, which is itself understood in technical terms. Patients become objects of this technique, more or less "compliant" to management by physicians. The incorporation of thousands of incurably ill AIDS patients into this system destabilized it and exposed it to new challenges (Feenberg 1995, chap. 5; Epstein 1996).

The key issue was access to experimental treatment. Clinical research is one way in which a highly technologized medical system can care for those it cannot yet cure. But until quite recently access to medical experiments has been severely restricted by paternalistic concern for patients' welfare. AIDS patients were able to open up access because the networks of contagion in which they were caught were paralleled by social networks that were already mobilized around gay rights at the time the disease was first diagnosed.

Instead of participating in medicine individually as objects of a technical practice, they challenged it collectively and politically. They "hacked" the

medical system and turned it to new purposes. Their struggle represents a counter tendency to the technocratic organization of medicine, an attempt at a recovery of its symbolic dimension and caring functions.

As in the case of the Minitel, it is not obvious how to evaluate this challenge in terms of the customary concept of politics. Nor do these subtle struggles against the growth of silence in technological societies appear significant from the standpoint of the reactionary ideologies that contend noisily with capitalist modernism today. Yet the demand for communication that these movements represent is so fundamental that it can serve as a touchstone for the adequacy of political theories of the technological age.

These resistances, like the environmental movement, challenge the horizon of rationality under which technology is currently designed. Rationalization in our society responds to a particular definition of technology as a means to profit and power. A broader understanding of technology suggests a very different notion of rationalization based on responsibility for the human and natural contexts of technical action. I call this "democratic rationalization" because it requires technological advances that can be made only in opposition to the dominant hegemony. It represents an alternative to both the ongoing celebration of technocracy triumphant and the gloomy Heideggerian counterclaim that "Only a God can save us" (Heidegger 1993a).

Is democratic rationalization in this sense socialist? There is certainly room for discussion of the connection between this new technological agenda and the old idea of socialism. I believe there is significant continuity. In socialist theory, workers' lives and dignity stood for the larger contexts that modern technology ignores. The destruction of their minds and bodies on the workplace was viewed as a contingent consequence of capitalist technical design. The implication that socialist societies might design a very different technology under a different cultural horizon was perhaps given only lip service, but at least it was formulated as a goal.

We can make a similar argument today over a wider range of contexts in a broader variety of institutional settings with considerably more urgency. I am inclined to call such a position "socialist" and to hope that in time it can replace the image of socialism projected by the failed communist experiment.

More important than this terminological question is the substantive point. Why has democracy not been extended to technically mediated domains of social life despite a century of struggles? Is it because technology is incompatible with democracy or because it has been used to suppress it? The weight of the argument supports the second conclusion. Technology can deliver more than one type of technological civilization. We have not yet exhausted its democratic potential.