The Turn to Technology in Social Studies of Science

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This article examines how the special theoretical significance of the sociology of scientific knowledge (SSK) is affected by attempts to apply relativist-constructivism to technology. The article shows that the failure to confront key analytic ambivalences in the practice of SSK has compromised its original strategic significance. In particular, the construal of SSK as an explanatory formula diminishes its potential for profoundly reconceptualizing epistemic issues. A consideration of critiques of technological determinism, and of some empirical studies, reveals similar analytic ambivalences in the social study of technology (SST). The injunction to consider "technology as text" is critically examined. It is concluded that a reflexive interpretation of this slogan is necessary to recover some of the epistemological significance lost in the constructivist move from SSK to SST.

For science-watchers of all kinds, an especially intriguing event occurs when a science declares an interest in a new object. It is at this point that we sometimes find unusually explicit claims about the scope and applicability of the science, about its ability to transcend established boundaries, and about its relevance for the new object domain.[1] These programmatic discussions are revealing, because they often include representations of the form and structure of argument (and explanation) that characterize that science. In addition, attempts to "apply" an existing analytic perspective to a new object reveal (perhaps more clearly than is evident from the routinized day-to-day work of the science) basic, taken-for-granted assumptions about the character and status of that science. In short, the application of a science to a new object

provides a useful occasion for discovering more about the explanatory rhetoric that sustains that science.

The "science" I have in mind is the sociology of scientific knowledge (SSK) and the "new object" is technology. No matter for the moment about my contentious characterization of this body of work as science. In recent years there has been an almost indecent rush by some sociologists of scientific knowledge (SSK) into the social study of technology (SST),[2] this author being no exception.[3]

What accounts for this move from science to technology? It is tempting to speculate on the importance of factors such as the increased availability of funds for research on the social context of technology (for example, the recent PICT[4] initiative in the United Kingdom); this situation in turn reflecting a heightened emphasis on the need for "useful" ("policy-relevant") social science research. Whereas SSK has been generally concerned with "pure" academic research, SST has the rhetorical appeal of potential utility.[5] However, this kind of speculation does seem an essentially "weak program" type of explanation for the move (cf. Bloor 1976). In particular, this line of reasoning fails to account for the *content* of SST explanations. Although it suggests why a different kind of object is the target of explanation, it does not tell us why the same form of explanation is being applied, nor do we learn much about the implications of this application.

A notable feature of the move is that the sociologists involved have thus far been less interested to account for the move than to demonstrate its possibility. For example, Pinch and Bijker ([1984] 1987) are more concerned to establish that the social constructivist perspective can be applied to technology than to explain why this possibility became apparent.[6] This lack of reflexive attention to the question of what accounts for the move from science to technology can be understood as symptomatic of fundamental assumptions about the status of social analysis and explanation. In particular, I suggest, a lack of reflexive sensitivity puts us in danger of forgetting the strategic theoretical significance of the sociology of scientific knowledge. We now need urgently to assess how the strategic value of SSK is affected by the move to SST. In short, what is gained or lost by the turn to technology in social studies of science?

This article aims to address this question.[7] It also attempts to examine what this move reveals about the rhetorical structure of SSK. What is its status? What has been achieved? Where have we got to and what comes next? In particular, what becomes of the original potential and implications of SSK when it finds itself a new object? This article does not attempt to answer these questions in full but merely tries to set the stage. In particular, the discussion

focuses on relativist-constructivist versions of SSK and SST, rather than on other variants (for example, the actor-network and translation models: Callon 1980, 1986; Latour 1987; Law 1987).[8]

The first part of the article outlines what I take to be the strategic significance of the relativist-constructivist perspective in social studies of science. I suggest that despite its potential, SSK has failed to develop some of the more radical implications of relativist-constructivism. This failure is manifest in the fact that certain key analytic ambivalences in SSK have yet to be exploited. The second part of the article considers the consequences of this state of affairs for the application of SSK to technology. It identifies similar ambivalences in SST and suggests that these are symptomatic of the way in which technology has been conceptualized as an "object" amenable to treatment by the relativist-constructivist formula. Finally, by examining three different ways of construing "technology as text," the article considers how the strategic significance of social studies of science can be recovered when treating technology.

Although the discussion takes the form of a plea for greater reflexivity, opportunities for reflexive experiments with form are passed over in this article.[9] The form of the argument is thus "univocal," apart from the passage immediately below, when the combined voices of the entire social studies of science and technology community (including mine) are goaded into one brief interjection.

Progress in SSK

A more provocative way of posing the central question of this article is to ask to what extent SST is likely to (or perhaps already has) repeat(ed) the same mistakes as SSK.

Mistakes! What Mistakes??!

Sorry, sorry. An outrageous lapse into asymmetry, I know. I apologize. How *dare* I presume actually to be able to discern "mistakes"?! I was just looking for a new way of raising the question of progress in the sociology of science. At the point at which SSK finds itself a "new" object, it seems especially pertinent to inquire about the direction, status, and progress of the enterprise. The early arguments about the deficiencies and inadequacies of alternative (prior) positions (for example, of teleological accounts, of rationalist philosophy, of the "received view," of Mertonian accounts, and so on) imply that SSK is to be preferred to its predecessors. So it seems appropriate to ask whether SSK admits that it too may in time become a predecessor to

a preferred (new) perspective. To do so, would be to admit that there are features of the SSK position — unkindly referred to above as mistakes — which are not as sound as they currently appear. On the other hand, not to admit that SSK can be superseded would be an extraordinary denial of the self-referential implications of SSK. It would suggest that whereas the relativity of truth holds for all other types of knowledge enterprise, SSK is to be considered a special case! This, of course, is the very thing that some advocates of SSK have said they wanted to avoid: a horrendous repetition of Mannheim's mistake. Without admitting (this kind of) reflexivity, as Bloor (1976) has argued, the sociology of scientific knowledge would be a standing refutation of itself.

This unpleasant dilemma — either admit to mistakes or claim special case (and hence self-refuting) status — is the corollary of an intriguing paradox at the heart of the programmatic claims of SSK. Although some writers suggest that SSK is (as it should be) capable of construing its own enterprise as (merely) another temporary style of knowledge production, it is not at all clear how SSK envisages the circumstances of its own demise. If SSK continues forever, it will refute its own relativistic tenet by constituting a contrary empirical example that supports the argument of its (nonrelativist) opponents. If, on the other hand, it is superseded, this will once again demonstrate its central argument about the contingency of any theory, thereby proving itself worthy of continuing.[10]

Unfortunately, this paradox (and its associated dilemma) has yet to be explored or confronted by more than a few scholars working in SSK. Instead, it has either been ignored or simply not noticed.[11] Practitioners of SSK have tended to adopt an attitude of "getting on with the job" as a preference to getting bogged down in what they view as unproductive philosophical conundra at the level of programmatics. One interesting consequence of this attitude is that certain analytic ambivalences remain central to the practice of SSK. The practical correlate of the programmatic dilemma identified above reemerges in the course of SSK argument.

Analytic Ambivalence in SSK Practice

Let us first review the essential features of the structure of a SSK argument. Without undue caricature, four main component moves can be identified:[12]

1. Select the account to be ironicized.

Typically, the account selected is a knowledge claim, a discovery, a mathematical formula, a scientific paper, a Nobel address, a scientist's interview response, and so on.

    2. Assert (or imply) that accounts quite different from that selected are possible.

The sociologist claims that it is possible in principle to supplant the selected account with another account. This is the "it-could-be-otherwise" move. There are various ways of achieving this assertion of alternatives: by general appeal to principles of historical and cultural relativism — in different times or in different places it could be otherwise — or by drawing upon the different accounts advanced by scientists embroiled in controversy.

    3. Portray these accounts as alternative accounts of the "same" "reality."

This move is important as a rationale for juxtaposing allegedly alternative accounts. Their difference is all the more marked, it is suggested, because they relate to the same (unchanging) "external reality." Thus (to expand the range of examples to include relativist-constructivist explanations beyond sociology of scientific knowledge): different legal/societal definitions of the same (deviant) act, different news reports of the same events, different medical classifications of the same drug, and different scientific knowledge of the same world. This invocation (either implicitly or explicitly) of a purportedly extant reality, to which varying definitions (constructions) relate, is a realist maneuver crucial to this style of relativist argument.

    4. "Explain" the "difference" in accounts by juxtaposing a description of antecedent circumstances.

Examples of such circumstances include social and cognitive interests, the activities of certain key social groups (or core sets), and so on. Notably, the sociologist's own account of these antecedent circumstances is not — in the course of explanation — subjected to move 2; attention is not drawn to the fact that it is possible in principle to supplant the sociologist's own "explanatory" account with another.

The central analytic ambivalence of this style of relativist-constructivist explanation has been documented elsewhere (Woolgar 1981, 1983; Woolgar and Pawluch 1985).[13] The relativist argument ironically depends on a practical (that is, "discursive" or "textually embedded") realism, both with respect to the purportedly extant reality underlying scientists' constructions

and with respect to the antecedent circumstances recruited as explanations. We thus see that the programmatic relativism gives way to a realism in practice.

One response to this ambivalence is to denounce explanatory practice in SSK as inconsistent and to urge its abandonment. Typically, this is the response of philosophers antithetical to social studies of science (for example, Laudan 1981). An alternative is to view such ambivalence, not as a problem or obstacle, but as an opportunity for exploring alternative modes of social science accounting (Ashmore 1989; Woolgar and Ashmore 1988). If current conventions of explanation constrain our attempts to explore the ramifications of relativist arguments, we need to consider what is gained by modifying our reliance upon these conventional forms. It is this line of argument that provides a rationale for recent textual experiments, "new literary forms," and other explorations in reflexivity (for example, Ashmore 1989; Mulkay 1985; Pinch 1988; Woolgar 1988c).

The Strategic Significance of SSK

As yet, however, there have been few attempts to exploit the analytic ambivalence engendered by reliance upon conventional argumentative formats. As I point out in this section, one adverse consequence of this is that the original strategic significance of SSK is compromised.

In an obvious sense, the substantive focus of SSK is the issues and concerns of epistemology. The sociology of science has been characterized as "epistemologically relevant" (Campbell 1978), as a contribution to "epistemic sociology" (Coulter 1989, chap. 1), and as dealing with "epistemic matters" (Lynch 1989). One can also account for recent wranglings between philosophers and sociologists of science as a contest for the same epistemological domain (for example, Bloor 1981; Laudan 1981). Epistemic practices include visual and textual representation, argumentative discourse, making interpretations, knowing, being certain, explaining, understanding, using evidence, reasoning, and so on. Since such practices are (reckoned to be) foundational to a huge variety of actions and behavior, the significance of SSK clearly goes beyond its ability to enlighten us about science. Its significance lies not just in providing more or different news "about science" but in its potential for reevaluating fundamental assumptions of modern thought. However, as we shall see in the example of the "hardest possible case" argument, this potential has been stunted by the unwillingness (or inability, see note 11) to press the reflexive consequences of SSK argument.

It is often suggested that the significance of SSK lies in its profound implications for many other areas of scholarship (for example, Woolgar 1991, 26). When construed as part of (or arising from) the sociology of knowledge, the results and findings of SSK also have direct implications for our understanding of all other kinds of knowledge production.[14] If it can be demonstrated that these are also amenable to treatment under the sociology-of-knowledge rubric, then it follows that we can proceed with increased confidence in the social analysis of all other forms of knowledge. Collins (1981) has articulated this strategic value of SSK in describing the "empirical programme of relativism" (EPOR):

> It would be very satisfying if the establishment of a piece of knowledge belonging to a modern mainstream science, with substantial institutional autonomy, could be described in terms of all three stages of EPOR. The impact of society on knowledge "produced" at the laboratory bench would then have been followed through in the hardest possible case. (P. 7)

Elsewhere, Collins elaborates:

> When I talked about a "hard case," I meant it in the technical sense which I thought was common usage — namely that if one wants to prove a general thesis you endeavour to prove it for the case where the thesis seems *least likely to hold*. The idea is that if you prove it for the case where it seems least likely to hold, it is fair to generalise to cases where it seems more likely to hold, whereas one has no warrant for generalising in the other direction. (1982, 142; Collins's emphasis)

Although this argument seems straightforward, it is not hard to see that this rationale depends on a series of unexamined postulates of adequacy. What exactly is to count as "prove," "hold," "generalize," and "warrant" in the argumentative work of EPOR itself? Are practitioners of EPOR content with the observation that, as members of the core set of SSK researchers, their own efforts to prove, hold, and so on are socially determined by the "impact of society"?[15]

More telling for present purposes are questions about the notion of hardness. For Collins, the "hardness" of knowledge corresponds to a low likelihood that the relativist thesis will hold.[16] And "least likely to hold" is equivalent to "what most people would say is this case (. . . the sense . . . which I thought was common usage)." Now, as befits the skeptical current of this kind of relativism, we might want to stress the interpretive flexibility of this remark. In line with the way the matter is posed in, say, the social problems and deviance literature, we could ask *for whom,* in *what circumstances,* on *what occasions, how,* and *why* does this appear hard (for example, Spector and Kitsuse 1977)?[17] In asking these questions, we would be sug-

gesting that there is no warrant for privileging hardness as an actual, inherent property of the object of study, any more than there is for any property of natural phenomena.[18] In other words, hardness is not given, it is constructed (attributed, constituted, rendered, an occasioned accomplishment); it does not reside in the object of study but is rather constituted through artful representation of the object.[19]

One result of this reflexive application of constructivism is the initiation of a program of investigations into the character of social science argument.[20] We learn that SSK constitutes its own hardness by way of a rhetorical contrast between the work of the analyst and the work of the scientists being studied; between the representational activities of the sociologist and those of his or her scientist-subjects. Whereas the latter are presented as amenable to relativism, the potential application of relativism to the former is played down. This rhetorical contrast amounts to a claim that different classes of representational activity are differentially susceptible to relativism. In other words, the analyst, the self in the explanation, purports to operate at a level "higher" than (different from) the subjects of study.

This practical or de facto assignation (in the course of representation/ argument) of a difference in levels is hardness in another guise. The harder our own argument, the less likely it seems susceptible to the kind of relativism we apply to the subjects of study. Hardness, the lack of susceptibility to relativism, is equivalent to the distance we establish between representational practices that we portray as susceptible to relativism and those that are not.[21] The greater the distance, the harder the case. So hardness is also a measure of the work needed to indent or collapse the distance established between analyst and object. As Latour has pointed out, the conviction of the sciences is built upon just this ability to act at a distance. The most convincing argument is precisely that which allows the analyst to "act upon" (explain, interpret, represent) phenomena while remaining distant from them (Latour, [1986] 1990, 1987). The rhetorical requirement is that the analyst-self can speak authoritatively about the phenomenon without, as it were, being contaminated by the phenomenon itself.[22]

As a result of the reflexive application of relativism-constructivism, we see that hardness is socially contingent; it is a practical accomplishment. This deconstruction of hardness thus reaffirms the power of the SSK formula. But at the same time, as we have already suggested, SSK ironically weakens its claim to theoretical significance. As more and more demonstrations of the social character of scientific knowledge emerge, so our preconceptions about the privileged status of science slowly change. The whole objective of the SSK project is to attenuate the hardness associated with scientific knowledge.

But the more the application of relativism to scientific knowledge is accepted, the less it is clear that SSK is dealing with the hardest possible case. What is important here is that this suggests that there might be a yet harder case to crack than the hardest possible case.

What might this case be? Recalling that "hardest" means the least likely place where the relativist thesis can hold, and that hardness also reflects analytic distance, we might construe "Self" as a candidate for a yet harder hardest possible case. By self I mean the self-in-the-text, the voice of the analyst/writer/author as it appears (or rather, as it conceals itself) in the course of argument (writing, speaking, representing). Note that the application of relativism to the embedded self-in-the-text is meant to suggest something different from many current sociological and psychological approaches. These approaches tend to construe self as a topic disengaged from the representational work it sustains. They provide theoretical discussions of the role of the self or the "idea" of self; historical portrayals of changing conceptions of self. While such approaches are interesting, they tend not to interrogate the self in action. The Self we are concerned with is the Self that sustains representational practice. This kind of Self can be construed as a yet harder case than science since, I suggest, it is even less likely that the relativist thesis can be applied to Self than to scientific knowledge.[23]

Whatever the particular merits of (this kind of) Self as a possibly yet harder hardest possible case, the important general point here is that the reflexive application of SSK yields a further domain of possible targets for analysis. Here then we come to the crux of the matter. The theoretical significance of SSK is not (just) that it tackles *the* hardest possible case but that *in virtue of its reflexive application,* it has the capacity to generate more and more "yet harder hardest possible cases." This should not be viewed as a defect but as a positive feature of the enterprise. The analytic ambivalence that stems from apprehending SSK as an explanatory formula needs to be exploited rather than treated as an embarrassment. Then we can see that far from being regressive, the reflexive application of SSK is thoroughly regenerative. The ultimate significance of SSK, in other words, is that it contains within itself the dynamic basis for the iterative reconceptualization of epistemic matters. It is in virtue of this dynamic that SSK has the "potential for reevaluating fundamental assumptions of modern thought" (Woolgar 1991, 25).

To summarize the argument thus far, we see that the potential strategic theoretical significance of SSK has been compromised by an unwillingness to confront the paradox at the heart of its programmatic claims and to exploit the analytic ambivalences in its practice. At the start, the main butt of SSK

was objectivist philosophy. The radical promise of SSK produced great upset among this constituency. We can now appreciate that objectivist philosophy provided an initial catalyst for setting in train the dynamic of iterative reconceptualization. Unfortunately, however, this process is in danger of being brought to a halt by the desire to establish SSK as an explanatory formula, a tool to be applied in different instances of scientific knowledge claims. In particular, the resistance to reflexivity means there has been no sustained effort to seek alternatives to realist discourse; we continue to ironicize the epistemic practices of others while privileging our own.

SSK Takes on Technology

In moving from science to technology, what becomes of the radical potential of SSK? Given that SSK has not gone far enough, can we only expect SST further to blunt the radical potential? This article suggests that, unfortunately, the discovery of a new object (technology) provides a convenient way of further avoiding the question of reflexivity. When construed as a formula for generating explanations in sociology (rather than, for example, an occasion for more fundamentally challenging the very idea of "explanation"), the application of SSK to a new object (technology) serves merely to reify the formula. This leads us to ask whether the move to SST is any more than a sideways turn.

In this second part of the article I address this question through a selective look at recent SST. One impetus for the current expansion of the social study of technology is the application of many of the ideas and approaches of SSK to the study of technology. Thus we now find the same post-Kuhnian critique of preconceptions about technology as was previously applied to preconceptions about science. This critique produces the following kinds of argument (the appropriate item corresponding to the SSK formula is in square brackets):

> Distinctions between the technical [scientific] and the social must be broken down. Social analysis should attend to the content of technology [scientific knowledge]. The role of the great individual engineer, inventor [scientist, discoverer] must be seen in social context. Technological [scientific] growth can no longer be thought of as a linear accumulation of artifacts [facts], each extrapolated from an existing corpus of technological achievement [scientific knowledge]. In short, technology [science] involves process as well as product, and technological artifacts [scientific facts] are to be understood as social constructs.[24]

Pinch and Bijker ([1984] 1987) articulate these parallels between science and technology with reference to EPOR. They stress the interpretive flexibility associated with the design and interpretation (use) of technological artifacts; there is no unique (necessary) way of designing (or interpreting and using) technology; designs and interpretations (uses) vary across time and between different groups and cultures. When competing views and ideas come into conflict, the upshot of the ensuing controversy is determined by various social contingencies. The recommendation for sociologists is to follow EPOR by mapping the passage of controversy and the formation of consensus, thereby documenting the social processes (especially the mechanisms of closure and consensus formation) whereby technological artifacts come into being and are accepted.[25]

Analytic Ambivalence in Critiques of Technological Determinism

Many SST writers take particular issue with the notion of "technological determinism." For example, in the introduction to their influential collection, MacKenzie and Wajcman (1985, 4 ff.) point out that the view that technology has effects (or impact) upon society entails two main assumptions. First, technology is construed as an independent factor in social change, something presumed to be "outside" society, either metaphorically or literally. The activity of technologists is construed as independent of society; technologists are thought to apply the discoveries of science, turning them into techniques and devices that then impinge upon society. Second, it is assumed that changes in technology cause changes in society.[26]

Against these assumptions, MacKenzie and Wajcman argue: First, there are many instances when devices judged useful and even essential were not taken up or were effectively resisted. This suggests that characteristics of society play an important part in deciding which technologies are adopted. Hence technology cannot be construed as a factor "independent" of society. Second, the same technology can have different effects in different situations. Hence technology must be seen as only one of a variety of factors that cause change. Third, this suggests that determining the effects of a technology is an intensely difficult and problematic exercise, that one requires a good theory of how society works, an understanding of the overall dynamics of society, before being able to specify the effects of a technology.

These three important observations establish the necessity that SST does not adopt or take for granted definitive depictions of the actual character of

a technology, what it can or cannot do, and so on. However, MacKenzie and Wajcman add an important rider. Just because the effects of technology are complex, they say, this does not entitle us to assume that technology has *no* effects. This is a significant remark because it reveals the authors' commitment to (a species of) causal explanation in their analysis of technology. Theirs is not an argument against construing technology as a causal factor. Rather it is a statement of the technical difficulties involved in singling out the effects of technology as a *particular* causal factor.

I want to suggest that this commitment to causality tends to compromise their arguments against the autonomy of technology. The invocation of a causal factor implies that it is possible adequately to describe the key features and characteristics of the entity in question. But this runs counter to the principle of interpretive flexibility associated with the social shaping of technology. The construal of a technology as a causal factor seems to imply that there are definitive, identifiable features and characteristics of that technology, whereas the central thrust of social shaping is to suggest that such features and characteristics are contingent, that any such features we would wish to attribute to a technology are the temporary upshot of a series of complex social (definitional) processes, largely due to the efforts of particular social agencies (groups). Or to put the point another way, their invocation of a technology as a cause implies the possibility of providing a definitive description of that technology.

This point requires specific clarification. I am not claiming that the depiction of technology as a cause requires that all questions of adequate description of that technology have first to be settled in some final or absolute sense.[27] For example, we are familiar with claims that "Chernobyl" caused milk contamination, where what exactly Chernobyl consists of is, in principle, open to an indefinite number of further inquiries, requests for clarification, and the like. My point is that at the moment of the construal of this causal association, in the course of formulating cause in this way, the reference to Chernobyl passes as adequate. It is in this sense that causal talk entails the local accomplishment of a practically adequate description of "the technology." Although their critique of technological determinism draws on the principled difficulty of describing the attributes of the technology in question, when speaking of technology having effects, MacKenzie and Wajcman seem to construe this as no more than a te.hnical difficulty.

MacKenzie and Wajcman explicitly nominate some technologies as candidates for the social-shaping hypothesis. This underscores the interpretive flexibility of technological capacity; what a technology can do is essentially uncertain; what "we" subsequently take a technology as capable of doing is the

result of our adoption of the contingent outcome of a complex definitional process. But MacKenzie and Wajcman also suggest that some technologies do in fact have self-evident attributes and capacities. For example (1985, 7),

> Technology's consequences are directly biological and ecological as well as social. Technologies can and do feed, clothe and provide shelter for us; they can and do also kill and poison. Technologies can preserve or degrade our environment.

The problem is that it is not clear what warrants the analytic distinction between technologies that are to be taken as liable to the postulate of interpretive flexibility (and thence social shaping analysis) and those whose attributes are to be treated as unproblematically given. It is tempting to answer that for certain technologies the effects are self-evident, perhaps even incontrovertible. But this would be highly unsatisfactory since, in my view, the whole point of interpretive flexibility is that apparent "self-evidence" and "incontrovertibility" are social accomplishments that are subject to change. Our recourse to self-evidence merely buys into one current definition. And it would be a pity to limit the scope of the theory to technologies whose impact currently happens to be controversial. Another answer admits that taking a particular definition as given is unsatisfactory but that at least this is the current consensus on the matter. Again, this is disappointing, insofar as it is unclear *whose* consensus this is and how (and when and why) it was achieved.[28]

Analytic Ambivalence in Empirical SST

Using the example of MacKenzie and Wajcman's essay, we have shown the analytic ambivalence in theoretical discussions of technological determinism. The promising disavowal of the concrete character of technology is compromised by the desire to continue causal analysis and by an absence of criteria for discriminating between technologies that are to be subject to interpretive flexibility and those that are not. A similar ambivalence characterizes the empirical literature, as we can see from a close examination of Langdon Winner's ([1980] 1985) celebrated essay—"Do Artifacts Have Politics?" Winner's essay is frequently cited as a good example of an argument that undermines the notion that technologies are inherently neutral (MacKenzie and Wajcman 1985, 7).

Winner begins by noting the position that what matters is not the technology itself but the social or economic systems in which it is embedded. This position, says Winner, has the advantage of countering naive technological

determinism — the supposition that the generation and effects of technology proceed from a dynamic internal to technology — but has the disadvantage of suggesting that the character of the technical things themselves does not matter at all. In a way that parallels the call by sociologists of scientific knowledge for attention to the content of scientific knowledge, Winner says we have to take technical artifacts seriously, that we need to attend "to the characteristics of technical objects and the meanings of those characteristics" (Winner [1980] 1985, 27).

Winner argues that there are two senses in which technical things can have political qualities. First, technologies can have political qualities in the sense that they are designed (consciously or unconsciously) so as to have a particular social effect. This is contrasted with the use of technologies for certain purposes (like the use of television to sell a political candidate); Winner suggests that a given device can be "designed and built in such a way that it produces a certain set of consequences logically and temporally *prior* to any of its professed uses" ([1980] 1985, 30; Winner's emphasis). Second, argues Winner, certain other technologies are "inherently political" in that the adoption of a given technical system actually requires the creation and maintenance of a particular set of social conditions as the operating system of that environment. For example, the existence of nuclear power plants *requires* the existence of a techno-scientific-industrial-military elite to take charge of them. The atomic bomb is an inherently political artifact because "its lethal properties demand that it be controlled by a centralized, rigidly hierarchical chain of command closed to all influences that might make its workings unpredictable" (Winner [1980] 1985, 32-33). Alternatively, says Winner, a given kind of technology may not require particular social and political relationships but may be strongly compatible with them. Thus, for example, solar energy is more compatible with (but does not necessitate) a democratic egalitarian society than are energy systems based on coal, oil, and nuclear power, since "technically speaking, it is vastly more reasonable to build solar systems in a disaggregated, widely distributed manner than in large scale centralised plants" (Winner [1980] 1985, 32).

Let us examine the anatomy of this argument. In the first sense of artifacts having politics, Winner uses the example of Robert Moses' bridges on Long Island. First, Winner deploys the ironicizing device of relativism: the technological artifact is said to be other than it appears. Winner suggests that the structural form of the bridges would excite little attention from the casual observer *but* that their form in fact embodies much more than meets the eye. Second, we are told of the designer's (Moses') motivations: social-class bias and racial prejudice. These motivations are derived from evidence provided

by Moses' biographer. Third, we are told of the effects of the technology in question:

> Poor people and blacks, who normally used public transit, were kept off the roads because the twelve-foot tall buses could not get through the overpasses. One consequence was to limit access of racial minorities and low-income groups to Jones Beach, Moses's widely acclaimed public park. (Winner [1980] 1985, 28)

Winner's use of the example of Cyrus McCormick's introduction of pneumatic molding machines has a similar structure. First, we are told that the introduction of molding machines *seems* a step to modernize the plant and increase efficiency. We are thus forewarned that things are other than they seem. Second, we are told that McCormick wanted to weed out the skilled workers who had organized the local union. The technologist's motives are thus revealed. Third, we are told the outcome, the facts: that the new machines "actually" produced inferior castings at a higher cost than the earlier process and that, after three years, the machines had destroyed the union. "The development *must* be seen in a broader context [of American political history and labor union-employer conflicts]" (Winner [1980] 1985, 29; emphasis added).

Note that in both stories, the motivations of the designer are rendered consistent with the effects of the design. This is despite the frequently noted phenomena (a) that effects of technology frequently diverge from the intended effects and (b) that a whole series of different effects can be said to result from the same technology. Ironically, the appeal of these stories lies in part in the display of a "rational" connection between the revealed (that is, constructed) consequences. More important, however, is the dependence of these stories on definitive accounts of *the* outcome of the technology. Despite the argument that the outcome or impact of technologies is contentious, that it is highly problematic to nominate one or other effect as arising from technology per se rather than from other social "factors," each of these stories unproblematically nominates *the* outcome (effects) of a technology.

This last feature of Winner's account is yet more pronounced in his claim for the inherently political quality of some technologies. In order to present technology as either requiring or being compatible with a particular form of social organization, Winner advances a definitive version of the capacity or effects of that technology. For example, he says, "It *is vastly more reasonable* to build solar systems in a disaggregated, widely distributed manner than in large scale centralised plants" (emphasis added); he refers to "the lethal properties" of the atom bomb, and so on. Once again, I should stress that I do not wish to contest these versions of technical capacity or of what counts

as reasonable, so much as to note that Winner makes his case by treating as definitive what might elsewhere be treated (in line with the relativist-constructivist premise about interpretive flexibility) as essentially contingent and contestable versions of the capacity of various technologies. He is not concerned to deconstruct these particular versions of technical capacity, although from the point of view of a broad constructivist commitment, they are clearly part of the phenomena to be investigated.

We see that the three-part structure of these arguments is a modification of the SSK formula described earlier. A technology is selected (move 1). Its "apparent" character is ironicized (moves 2 and 3), in particular, by advancing a preferred reading of the character of the technology. The basis for the preferred reading (an "explanation" of the difference between "apparent character" and preferred reading) is then articulated by invoking the motives or other antecedent circumstances of the technologist (move 4). In the SST examples above, an additional move follows. The preferred reading of the character of the technology is supported by a statement of the "actual effects" of the technology in question.

Technology as Object

The analytic ambivalence in SSK thus recurs in SST. Specifically, in empirical SST, relativism is applied only to certain selected technologies. More important, the deconstruction of the selected technologies depends upon what pass (in the course of the argument) as definitive versions of the capacity and attributes of these technologies. This occurs, despite the axiomatic appeal to the interpretive flexibility of the character and attributes of technology and the disavowal of technological determinism.

In the case of SSK, I suggested that this analytic ambivalence was the practical correlate of a paradox at the heart of a program that sought to treat epistemic practices unreflexively, that is, as a realm of phenomena construed to be essentially distant (and distinct) from the activities of the analyst. The recommendation was that this paradox be explored rather than ignored, for it is by this route that the potential for iterative reconceptualization can be realized. The analytic ambivalence in SST seems much less consequential than in SSK, precisely because technology practice is conceived as an activity more distant from that of the analyst. Even if SST allows the characterization of the analyst's work as epistemic (interpreting, explaining, adducing evidence), the same view is not applied to the work of the technologist practitioner.

This rhetorical distancing between subject and object (analyst and technologist) makes safe the application of a scheme of argument qua formula. Construed as a distanced object, the technologist is prevented from "talking back"; the argument can proceed safely (and largely predictably) in the knowledge that the analyst's practices are unaffected by those of the technologist. It is no coincidence, of course, that construed like this, SST has little of the bite and controversy associated with the treatment of scientific knowledge as an analytic object. How many philosophers are going to get upset at the contention that technologies are socially constructed? Not a lot! Where are the Larry Laudans and the Bill Newton-Smiths to say how outrageous is the social deconstruction of technology? Technological design is not, by and large, an honorific activity championed by a prestigious body of philosophical tradition. The fact that there are no philosophers to upset is disappointing, not just because it is fun to upset people, but because, as suggested earlier, such opposition is functional for working through the longer term significance of a critical challenge to traditionally held views.

Similarly, SST exhibits little of the counterintuition associated with the social construction of science. Whereas, at least at the time of its earliest formulation, the notion that scientific knowledge was socially constructed seemed to contradict commonly held perceptions about science, the suggestion that technology entails social process has little of the same effect. Of course, on certain occasions and for certain purposes, people act as if particular design solutions are the most rational available. But, I suggest, we are far happier about admitting that the achieved solution (a nuclear reactor) is the upshot of social and political machinations than we are about accepting the same claim for the construction of a solar neutrino.

Another way of making the same point is to say that, construed as the application of a preexisting formula to a new object, SST has no pretensions to be dealing with the hardest possible case. Nothing especially hard is claimed about technology; it is far more easily susceptible to relativism than scientific knowledge. Here again we see how the radical potential of SSK is compromised. The empirical program in the social construction of technology does nothing to encourage us to consider what other hardest cases might be tackled or to consider what exactly hardness consists in.

How then are we to recover something of the original important dynamic potential of SSK in the turn to technology? It follows from the argument above that the problem lies in the construal of technology as object and the adoption of SSK as an immutable mobile, a formula for disinterested application to a disembodied object. We therefore need to find a way of retrieving the productive danger of reflexive practice. An initial suggestion is that we

should try to develop one of the more interesting responses to the construal of *technology as text.*

Technology as Text 1: The Instrumental Response

Let us distinguish between three main responses to the slogan: "technology as text." A first "instrumental" response merely reemphasizes the interpretive flexibility of the character and capacity of technology, as a preliminary to the kind of relativist-constructivist argument already outlined. It counters the view of technological artifacts as simply docile objects with fixed attributes (uses, capabilities, and so on). It asserts the malleability of the character of technological artifacts and thus provides the possibility of a "strong program" in the sociology of technology (Bloor 1976; Pinch and Bijker 1984). The very content (technical capacity) of the artifact can be said to be understood sociologically, as the upshot of a series of contingent social processes, without regard to the perceived success or failure of the technology, and in terms other than a (sometimes "inevitable") path of progress. This route enables us to identify the process of the construction of the text and, in particular, its insinuation within a network of "actors" (Latour [1986] 1990) so as to constrain or minimize the range of possible "readings"; in other words, so as to produce consensus as to technical capacity.

The instrumental reading of technology as text also suggests that many discussions and analyses of the impact of technology may be premature, in the sense that they tend to adopt a relatively fixed view of the capability of the technology in question. For such discussions, impact is primarily a question of the circumstances of deployment and use of technology; its (presumedly inherent) capacities are constrained or enhanced, depending upon how it is handled. By contrast, the view of technology as text suggests that the likely "impact" of new technology is "built in" during the process of evolution and design and reconstructed and deconstructed during usage. The currently fashionable dictum may well apply: subject to the constraints of the actor-network, it is the readers who write the text of technology.

Technology as Text 2: The Interpretivist Response

The instrumental reading of technology as text can lead to research aimed at discerning connections between organizational environment (under which rubric we might include organizational structure, management style, beliefs,

and culture) and the process of technological development: what kinds of environment enhance or impede the development of technology? This general formulation admits a variety of kinds of possible study, including studies that attempt to discover how practitioners themselves articulate "connections" between technological environment and practice (cf. Woolgar 1987b).[29]

The notion of technology as text thus also suggests an interpretivist response: the study of the ways in which technology texts are written and read. For example, the structure and capabilities of a technological artifact can be read as embodying the form of organization within which the artifact takes shape. In other words, technical content can be read as isomorphic with organizational context. This is, of course, a reading that follows Durkheim's suggestion that objects are classified in societies in a way that reflects and extends existing social classifications: for example, ideas about space, or knowledge of the physical world reflects the basic material and social divisions of society; our apprehension of nature will display the organization and arrangement of our social institutions. In this instance, technological artifacts are reckoned capable of displaying the form of their generating organization.

The view that artifacts embody organizational form is an intriguing heuristic. However, it is important to stress that "embodiment" is an accomplishment, one of a number of alternative possible readings, and the upshot of reading the text in a particular way and for a particular purpose. For example, we might speculate that the reading of a technology for the conditions of its genesis may be attractive to certain captains of industry, because it provides the basis for a deconstruction of an opponent's claim to neutrality. That is, a particular claim about technical capability might be dismissed by reading the artifact for the antecedent circumstances of its production (for example, the motivations of the designers, their organizational style, and so on). By analogy with the technique of insinuating modalities when deconstructing a scientific opponent's knowledge claims, this way of reading a technology provides a means of undermining competitors' claims for technical capacity.[30]

The view that it is possible to read technology as text and, in particular, as embodying organizational form, seems to run counter to the more popular view that technologies actively *conceal* their own history. In Bachelard's terms, for example, the phenomeno-technique gains value precisely because it can be used without having to unpack (deconstruct) the theoretical work and past scientific achievements that it (actually) embodies. Useful technologies are opaque texts in this sense, black boxes par excellence. However,

the apparent contradiction is resolved when we recognize that both interpretations (technology as revealing organizational form, on the one hand; technology as concealing its history, on the other) are readings accomplished for different purposes. The former treats a technology for what can be gained by insinuating circumstances of its genesis, the latter reading for what can be gained by *not* having to attend to such circumstances. At the hands of the interpretivist response to technology as text, an important question is what in any particular situation makes one reading seem more plausible than another.[31]

Technology as Text 3: The Reflexive Response

We see that an initial (instrumental) response to the technology-as-text slogan reemphasized the interpretive flexibility of the capacity of technology and deployed this in a fairly traditional argument. The second (interpretivist) response takes the slogan to emphasize the accomplishment of textuality and leads to a program of study of how and why readings of technology are accomplished. A third response builds further on this latter approach by insisting that readings of the technology text are accomplished both by technologist subjects *and by the analyst* in the course of sociological argument.

In this last sense, technology as text provides a slogan for reestablishing an object that will rebound upon the analyst. This is done by reducing (perhaps removing) the distance interjected between analyst and object when the latter is viewed as a realm of practice essentially different from that of (the analyst's) argument. Under this rubric, what we apprehend as technology is to be construed as text, the production and consumption of which is on a par with our own writing and reading practices. In other words, our analysis starts from the position that the textuality of technologies and the textuality of argument is essentially similar.

By this means, we recover the initial SSK focus upon epistemic practices. We can ask how and why technologies can be read as relatively robust pockets of interpretation in a sea of interpretively flexible texts. Their robustness, or relative stability, consists in the extent to which they are credited with the capacity to act or to effect action. Whereas the effects of "ordinary" texts upon the reader are largely indeterminate, by contrast, technologies are texts with largely (designable and) predictable effects. The "how-and-why" question can be addressed, under this third rubric, in terms of the different representational (and other epistemic) practices involved in the apprehension and display of technologies and their effects, with particular

attention to the ways in which analysts' texts typically come off as second best. This might include studies of the ways in which particular classes of entity are privileged in discourse about capability, reliability, and dependability; about the role of various agencies of representation in assigning and discussing action, its consequences, and causes. This might lead, in particular, to questions about the nature of textual production, to whether and in what sense texts produced by machines are more robust than others.

The differences between these three ways of articulating the technology-as-text slogan can be understood as merely a matter of emphasis; the possibility of different interpretations of technological capability is uncontentious. But the differences can also be understood as a reflection of deeply divided epistemological assumptions that guide perspectives within SST. This can be demonstrated by reference to the more general argument about the relationship between text and meaning.

Nobody familiar in broad outline with neo-Wittgensteinian linguistic philosophy would want to argue that texts or other language items have fixed or inherent meanings. At the hands of Garfinkel (1967) in particular, the concept of indexicality is extended to suggest that all language items are indexical. But it is crucial to note that the indexicality of language items does not entail that language items can ever be "free of meaning," prior to their usage. The point is that they are always being used; in virtue of their very existence they are in usage. By analogy, the view of technology as texts suggests that it is pointless to conceive of a meaning-free technology. Like language items, technologies are texts that are always *embedded.* Winner's argument exploits the instrumental sense in which technologies are texts. He says that the technology in question can be read in at least two ways. Whereas Moses' bridges can be read as the unremarkable means of carrying automobiles from one place to another, they can also be read as the conspiratorial upshot of racial prejudice, or as consistent with the dynamics of a capitalist economy, and so on. In order to advance his preferred reading, Winner organizes his own text so as to interrelate motive, outcome, and technical capacity. He reembeds the technical artifact in question by wrenching it from one situation and placing it in another, thereby answering his question – Do Artifacts Have Politics? – in the affirmative. This analytic procedure thus trades on the textuality of technology by setting itself the task of (re)producing texts of technologies so that they can be read as political.

The move from instrumental to interpretive responses to the technology-as-text slogan occurs when we recognize that the issue is more than whether or not artifacts actually have politics. Winner's usage aims to displace the disfavored reading in favor of "what technologies are actually like." In other

words, for Winner, the two readings of technology ("neutral" or "political")
are not mere alternatives; the latter reading is the better, more reliable, true.
The interpretivist response espouses a measure of impartiality by proposing
that analysis deals with the ways in which readings are done, without
prejudice to their relative truth. From this point of view, the pressing analytic
issue is to understand the production, organization, and interpretation of the
textual character of technologies. Under this rubric, the answer to Winner's
question is: Yes, if you like. It is indeed possible to read a text as "having
politics." But what is it that makes one reading of the text (technology) more
persuasive than another? From this point of view, there is little analytic
advantage in merely pronouncing upon (or fighting for) one or another in-
terpretation, as if the role of the analyst is to discern the real meaning, in the
manner of a Winchean (Winch 1958) underlaborer. This would be equivalent
to legislating on the truth status of a scientific knowledge claim. From the
perspective of the interpretivist, the analytic work lies in acknowledging and
tackling the question of how some technology texts appear more persuasive
than others.

The interpretivist position further reemphasizes the essential indefinite-
ness (indeterminance, interpretive flexibility) of attributes (capacity, charac-
ter, make up, origins) of technology. However, the interpretivist position still
retains a privileged position for the analyst's own texts. Pushed along one
step further, the reflexive version of technology as text suggests that all
versions (descriptions, accounts) of technology be granted no greater author-
ity than any other outcome of textual production and interpretation. This
includes our own texts, in which we as analysts conventionally privilege our
own status vis-à-vis the relativized status of the texts of others. This suggests,
for example, that discussions of, in, and around technology might be fruit-
fully used to explore the privileging of Self. What is it about "her" textual
production that makes a mere author less than a technology in the predict-
ability of the effect of the product?

The move from interpretive to reflexive versions of the technology-as-text
slogan signals a significant change in underlying epistemological assump-
tion, and this change explains one of the chief objections to the "as-text"
metaphor. The interpretivist version implies the objective and transcendental
existence of a technology; along the lines of labeling theory in the sociology
of deviance, attention is focused upon different reactions to the "same
object." In other words, the essence of the technology is presumed un-
changed; it is merely being called, rendered, described as something differ-
ent. By contrast, the reflexive version takes a more ontologically agnostic
position. It includes the question: How is the reality of the technology itself

created, described, and sustained, and, in particular, how do the effects and capability of the technology relate to the effects and capabilities of the other entities in the text in which they are inscribed?[32]

But where does this get us? Does not this confusion of subject and object (the author as technology; the technology as text) merely muddy the analytic waters? Yes! That is exactly the objective! Pushing beyond the conventional distinction between analyst and phenomenon (under instrumental and inter-pretivist rubrics) provides a way of substituting a reflexive orientation for the formulaic character of existing analyses of technology. The "muddiness" is a deliberate tactic for recovering some of the analytic ambivalence lost in the transposition of SSK into a formula for applying to a "new" object. By asserting the principled equivalence of author-text and technology-text we highlight the analytic ambivalence involved in privileging one entity over the other. This then enables us to exploit this ambivalence in the way recommended for realizing the radical potential of SSK. We are brought again to the point at which we can see the potential for iterative reconceptu-alization of epistemic matters.

We have already suggested how this route enables us to recover something of the epistemological relevance lost in the move from SSK to SST. The particular epistemic matters at issue are the representation and constitution of abilities and capacities of entities, some of which come to be endowed with the status of "technology." Under the reflexive orientation to technology as text, we not only ask what makes the effects of one entity's actions (the outcome of a technology) more or less predictable than others (the writing of the author); we also ask what is involved in addressing this question within the constraints of textual conventions that privilege the author's actions.

Since all accounting procedures involve the use of what might be called "technologies of representation" (inscription devices, immutable mobiles, and so on), the reflexive orientation to technology as text addresses the question of hardness with a renewed emphasis. These technologies are viewed as texts that produce texts; in particular texts which constitute analyst-object relationships. They produce texts that provide for claims about the distance between self and other. In other words, technologies of repre-sentation can be said to achieve distance and thus enhance the hardness of our arguments. For example, a videocassette player not only brings the videoed subjects into view outside of their recorded environment. It also enables us to stop them, move them forward and backward and at different speeds. The manipulability of our videotaped subjects reaffirms their con-creteness qua "real entities." At the same time, this very manipulability backgrounds the role played by the operator of the text; its silent author

merely pushes the buttons, allowing the reality to display *it*self; as if the videocassette machine, rather than the operator, is responsible for the revealed images.

In describing (accounting for) technologies as the product of objects or forces outside ourselves, we underplay the sense in which we are enmeshed in the web of associations that makes technology what it appears to be. In particular, by attempting to *explain* technology, we are in danger of explaining it *away*, precisely in the sense that the technology becomes an object disengaged from the author and subject only to "social forces" apparently removed from the world of the analyst. The reflexive construal of technology as text is an attempt to interrogate in the web of associations through which our apprehension of technology is ordinarily constrained.

In short, technology is to be understood not just as a text that acts at a distance on *its* authors but as an entity that acquires this feature through only the relationships constituted in our own texts. The popularity of the Moses' bridge example is precisely Winner's ironic revelation of a semiotic character whose presence was hitherto concealed. In effect, Winner shows how Moses' bridge acts at a distance; Moses does not have to be there to have an effect on the poor blacks. What has not yet been grasped, however, is the significance of the observation that the claimed relationship between Moses and the blacks depends on *Winner's* successful action at a distance. Only as a result of Winner's deployment of a technology of representation can the bridges tie Moses into association with the blacks.

Conclusion

I have argued that the radical potential of SSK has been compromised because it has failed to interrogate its concept of hardness and thereby failed to exploit the analytic ambivalence at the heart of its practice. With a few encouraging recent exceptions, SSK has not addressed its own dependence upon conventions of realist discourse. Consequently, SSK fails to address the issue of representation at a fundamental level; it seems set to become another exemplification of the relativist-constructivist formula rather than an occasion for questioning the idea of applying formula altogether. In its formulaic incarnation, the aim of SSK is not radically to recast our conceptions of representation nor to seek alternatives to realist ontology. It has, instead, the more modest aim of bringing one form of knowledge (science) into line with others. This is not dismantling truth per se, merely substituting sociological (and sometimes literary) truths for those of science (Lawson and Appignanesi

1989; Woolgar 1988a, 1989). The most important upshot is that the dynamic of iterative reconceptualization, the capacity for SSK to revisit its core assumptions and to generate further hardest possible cases, is put in jeopardy.

The "application" of SSK to technology unfortunately provides a recipe for exacerbating these deficiencies, if not losing sight of the strategic significance of SSK altogether. Technology has been sought as merely another exemplification of the SSK formula rather than an occasion for questioning the idea of applying formulas. The important rhetorical consequence of this move is to buttress the presumed strength of the formula itself. SSK becomes a reified technique: a purportedly neutral instrument to be applied indifferently to more and more new kinds of object. In an unnoticed, but startling, irony the programmatic calls for opening the black box of technology depend on treating the conceptual and methodological baggage of SSK as no more than a black box.[33] The main consequence is that the analytic ambivalence, the question of the hardness of the phenomenon, and the epistemological significance of lines of exploration initially suggested by SSK — all stand to be lost.

These important features of SSK can be recovered, it has been argued, through a reflexive articulation of the notion of technology as text. The author-text and the technology-text must be put on the same footing if we are to recover the strategic theoretical significance of SSK. This must be done, not just by decrying the instrumental application of SSK to a new object but, as we have seen, by also reenacting the instrumental application of the reflexive critique of SSK at the point where it meets a new object.

Notes

1. Examples of an explicit programmatic claim might include, for instance, the argument for applying evolutionary theory to the study of human behavior.

2. Some preliminary indications of the interest in this direction are the excellent collections recently published by Laudan (1984), Mackenzie and Wajcman (1985), and Bijker, Hughes, and Pinch (1987).

3. The shifting interests of individual members of the SSK community can be identified from the changing topic of their case studies: Collins (from parapsychology and gravitational waves to expert systems), MacKenzie (from eugenics and statistics to guided weapons), Pinch (from parapsychology and solar neutrinos to technology in general), Woolgar (from pulsars, neuroendocrinology, and solid-state physics to artificial intelligence and computer software and hardware).

4. The Programme on Information and Communication Technologies (PICT) is an Economic and Social Research Council (ESRC)-sponsored initiative to promote social science research into the social and economic contexts of the new technologies. CRICT (Centre for

Research into Innovation, Culture and Technology) was established at Brunel University in October 1987, as one of a network of six PICT centers in the United Kingdom.

5. It could be argued that science and technology should never have been conceived of as analytically distinct topics in the first place; that their artificial separation is an unfortunate effect of the prestige associated with science and its widespread perception as the most superior of human activities. This is consistent with the effort to blur the boundaries between science and technology by reconceptualizing the analytic object of SSK/SST as "techno-science" (Latour 1987). Along these lines, we might note that only science has enjoyed a long tradition of attention from philosophers, whereas the philosophy of technology is barely developed. Also, by contrast with the teaching of natural sciences, academic institutions have been loath to institutionalize the teaching of technology until very recently (for example, the Faculty of Mechanical Sciences only became the Faculty of Engineering at Cambridge University as late as 1964).

6. Consequently, we are left uninformed both about the extent to which SSK might be applied to this particular move and about the implications for the explanatory status of the new venture. Can impartiality be retained as a result of the reflexive application of SSK in this situation? Do SSK practitioners offer the same kinds of answer as their scientist-subjects, when they themselves are the subjects of analysis? Compare the situation in which a natural scientist explains the reason for his or her move into a new domain in terms of the likely benefits for the new domain of his or her expertise. Would we sociologists be happy to accept that explanation at face value?

7. A subsidiary aim is to contribute to our understanding of relativist-constructivist explanations in general. Under what circumstances are such explanations modified or abandoned? What happens when the same form of explanation is applied to a new object?

8. It is worth stressing that the relativist-constructivist perspective is not the only way to study technology. The editors of the Bijker, Hughes, and Pinch (1987) collection outline two other distinct approaches: Hughes's technological systems approach and the actor network approach of writers such as Callon, Law, and Latour.

9. There is no justification for this last statement. There is no justification for this last statement.

10. Thanks to Diana Hicks for this formulation.

11. It is not clear whether this is a difficulty that is recognized but not taken seriously or whether it is not recognized as a difficulty at all. In the latter possibility it is, perhaps, a "seen but unnoticed" feature of SSK practitioners' routine accomplishment of social order, that is, of SSK arguments (cf. Garfinkel 1967). This suggests, in turn, that the recognition of (let alone the "confrontation" with) the difficulty will require a change in disciplinary conventions (and constraints) such that a different realm of the "noticeable" becomes possible.

12. For a full account see Woolgar (1983) and Woolgar and Pawluch (1985).

13. A parallel debate concerns the status of constructivist explanations in sociological analyses of social problems (for example, Kitsuse and Ibarra 1990; Ibarra and Kitsuse 1989; Schneider 1989; Pollner 1989; Best forthcoming).

14. This is the import of programmatic statements about the inadequacies of the classical sociology of knowledge in stopping short of taking mathematics and the natural sciences under its purview.

15. For a detailed analysis of the reflexive implications of Collins's arguments, in particular the issue of replication in EPOR's analysis of replication in science, see Ashmore (1988; 1989, chap. 4).

16. Collins (1982, 142) also says, "There is no exact relation between the *hardness* of a case and the *difficulty* of researching it." This seems reasonable if "difficulty of researching" refers

to the practical task of unearthing sources, organizing them, and undertaking analysis, since this aspect of research is distinguished from the business of persuading one's audience as to the plausibility of one's analysis. In this view, difficulty in research and difficulty of persuasion are separated. Unfortunately, this only holds good for those instances of research in which oneself is already persuaded. As soon as oneself is part of the audience to be persuaded, the distinction between difficulty and hardness breaks down.

17. I am not concerned to determine whether or not it actually is hard: this is beyond my jurisdiction as an impartial observer of SSK (the tenet of impartiality: Bloor 1976).

18. In this instance, Collins appeals to an implicit hierarchy of knowledge, ranging from weak (perhaps of the kind associated with religious beliefs or political ideologies) to strong (natural sciences and mathematics). Perhaps one ground for his taking the latter as unproblematically strong is that "most people" think of these areas of knowledge in those terms. The commonness of this conception is indicated by the observation that the superiority of the latter is taken for granted. Yet a quite different realm of objects of inquiry also comes into focus when we look carefully at what is taken for granted — namely, our ability to stand apart from phenomena.

19. This follows the SSK dictum that properties of objects are essentially equivalent to their use. Collins's (1975) example of temperature is still one of the best around.

20. Some answers to this question are beginning to emerge as we build a picture of the way hardness is constituted in the course of constructivist arguments: both in SSK and other kinds of relativistic sociological writing. For example, the use of irony (Woolgar 1983), ontological gerrymandering (Woolgar and Pawluch 1985), boundary work (Gieryn 1983), and R/A (reality/appearance) devices (Potter 1983).

21. We see how the equivalence between distance and hardness pertains in at least two different kinds of analyst-object relations. In the natural sciences, hardness means precisely the achieved difference (distance) between scientist and the "objects of the world": electrons are disprivileged, in that they are not permitted feelings, opinions, the capacity to "know" (do research), and so on. (Electrons are a good candidate for the TEA test. See note 23.) By contrast, many of the social sciences, especially those influenced by the tradition of phenomenology, tend to sacrifice hardness by stressing the similarity between their own Selves as analysts and their objects (which become "subjects" in the same move). And within the social sciences, of course, there are constant debates about the relative merits of hard and soft social science, coupled with anxious deliberation over its (possibly) scientific status. Significantly, the achievement of distance, the robustness of the self in explanation, depends upon the judicious use of what can variously be called technologies of representation (Woolgar 1989), inscription devices (Latour and Woolgar 1986), or immutable mobiles (Latour [1986] 1990).

22. Hence the rhetorical tension in accounts by Nobel laureates and the like: although uniquely responsible for the discovery of a phenomenon, they want to stress that anyone else could similarily have come upon the same phenomenon, had they been in the right place at the right time and so on (Woolgar 1981).

23. This last proposal merits some elucidation, particularly in relation to the sense of Self at issue here. Before tackling this task, it is worth noting that the proposal is supported by what I call the test of envisaged absurdity (the TEA test). In crude terms, the TEA test assumes a direct relationship between (a) the degree of horror and consternation provoked when a particular phenomenon is initially suggested for sociological study and (b) the evident fruitfulness of pursuing this apparently absurd perspective (*fruitfulness* means degree of debate and scholarly attention). Hence the greater the cries of outrage, the more fruitful the way forward. As precedent, I cite the counterintuitive reaction to initial proposals for a sociology of science and, in more specific detail, the degree of consternation on the part of objectivist and rationalist philosophers

at the proposals for a strong program in SSK. Although the test is not infallible (none are), the apparent absurdity of the idea of deconstructing Self is encouraging.

24. Fabricated quote, part lifted from Woolgar (1987a, 311).

25. Programmatic claims for SST involve an antagonistic characterization of deficiencies in earlier work. Thus, Bijker, Hughes, and Pinch (1987, 3): "This new type of technology study can be characterised by three trends in the sort of analysis attempted. Authors have been concerned with moving away from the individual inventor (or 'genius') as the central explanatory concept, from technological determinism, and from making distinctions among [*sic*] technical, social, economic, and political aspects of technological development." Pinch and Bijker ([1984] 1987, 21-24) criticize "innovation studies" for failing to take into account the content of technological innovation, and they criticize both "innovation studies" and "traditional" research in the history of technology for their asymmetric focus upon successful (rather than failed) innovations.

26. A variety of different levels and senses of "society" are used in these assumptions.

27. I am not saying that we are prohibited from using *any* version (definition, description) of the character (capacity) of a technology or that we should somehow try to avoid any formulation or reference to a technology that depends on some agency's definition of that technology. Such a prescription is, in any case, probably impossible, even if it were desirable. However, I *am* saying that we need to be much more aware of the way in which our use and reference to technology embody particular definitions and descriptions that are the work of others.

28. In insisting on a kind of *relentless* indeterminancy (interpretive flexibility), I have no desire to *contest* current consensus in the specific sense of proposing an alternative. Who am I to declare that a specific technology does *not* "kill and poison us"? Indeed, it would be consistent with the relativist-constructivist program to say that the analytic aim is the impartial deconstruction of stories (descriptions, evaluations, definitions, attributions) that involve technology: who says it poisons, under what circumstances did they say this, to whom, how, and why? Where the characteristics and capacities of a T are most "self-evident" and "obvious," these are precisely the cases that most urgently require deconstruction. For it is in these cases that the agencies of definition have done their work most effectively: the modalities that ease the task of recognizing where we can ask sociological questions — who, how, when — have been deleted.

29. At one point in Tracy Kidder's (1981) frequently cited account of the construction of a new computer, the hero (Tom West) manages to sneak into the building where a competing organization (DEC) is developing a VAX computer. Taking apart the printed circuits, he carefully assesses the structure of the competitors' machine and is reassured to find it is not quite as special as he had feared:

Looking into the VAX, West had imagined he saw a diagram of DEC's corporate organisation. He felt that VAX was too complicated. He did not like, for instance, the system by which various parts of the machine communicated with each other, for his taste, there was too much protocol involved. He decided that the VAX embodied flaws in DEC's corporate organisation. The machine expressed that phenomenally successful company's cautious, bureaucratic style. . . . "With VAX, DEC was trying to minimise the risk," West said. (P. 36)

West's appraisal thus suggests a potentia .y valuable sense of connection between environment and product.

30. In all cases, I suggest, the sense of the accomplished reading is its use. "Was this true [that artifacts embody organizational form]? West said *it did not matter, it was a useful theory.*" (Kidder 1981, 36; emphasis added).

31. Note how the argument of writers like Latour and Woolgar (1986) depends on the ironic juxtaposition of these two types of reading: "the actual historical embodiment of the artefact"

and "its evident opacity at the hands of its scientist-users" (cf. Woolgar [1983] on irony in social studies of science).

32. Certain objections to the textual metaphor reveal an ontological partiality. For example, it is said that the as-text metaphor is inappropriately applied when the entities in question (such as culture and technology) exhibit greater propensity for change than usually associated with texts. Thus, it is said, whereas technologies (and cultures) change, sometimes leaving no trace of predecessor forms, texts do not change; the same text merely gets reinterpreted. This objection has the text constant and portrays the technology as changing. Interestingly, the instrumental and (to some extent) the interpretivist positions are almost exactly the inverse of this objection: for them, the technology stays constant while its text (interpretation) changes.

33. Thanks to Leslie Libetta for this particular way of expressing the point.

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