1980

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1980. *Transactions of the Nebraska Academy of Sciences,* VIII:225-236.

THE IDEA OF TECHNOLOGICAL PROGRESS AND ITS PROBLEMS

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Recently the problem of scientific progress has been one of the most widely discussed topics among historians and philosophers of science. But little has been said on the problem of technological progress. I suggest that theories of technological progress can be divided, first, into cognitive and non-cognitive; then cognitive can be subdivided into cumulative and problem-solving; non-cognitive can be divided into material well-being and moral and spiritual well-being. After examining different versions of the cumulative theory, I conclude that technology is not intrinsically cumulative; whether technology is cumulatively progressive is a matter of goals extrinsic to technology. I argue that Laudan's recent problem-solving theory of scientific progress seems to fit technology exceptionally well; but this notion of progress turns out to be rather emaciated. The material well-being model of technological progress is the position that technology can endow human life with "new inventions and riches." This model raises many thorny problems concerning what constitutes man's material well-being. Finally, the moral and spiritual well-being model states that technology can improve man's ability to achieve moral and spiritual goals; but what these goals are varies widely from position to position. My general conclusion is that technology does not, with two exceptions which are minimal, contain any intrinsic direction toward betterment. I then briefly note some implications of this conclusion.

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INTRODUCTION

The liveliest topic of discussion in the philosophy of science in the past decade has been on the nature of scientific progress. The focus on this problem marks a striking change from the beginnings of the professionalization of the philosophy of science in the 1920s. The Logical Positivist approach toward the philosophy of science consisted in the attempt to find, by detailed logical analysis, the timeless and universal meanings and structures of all scientific knowledge (*e.g.,* the meaning of "law," "causality," "probability," and the pattern of validation, the logical structure of scientific theories). This approach regarded the psychology of scientific discovery and the evolution of scientific concepts as largely irrelevant to an understanding of the scientific enterprise. Beginning in the late 1950s, the positivist approach to science came under increasing attack. The assault was led by Hanson (1958), Kuhn (1970), Toulmin (1953), and Bohm (1957), and it was based primarily on the thesis that presuppositions play a dominant role in science. Since these presuppositions were time-rooted, the new approach emphasized the history of science; and the examination of the history of science inevitably led to inquiry into the progress of science.

The emphasis on the importance of presuppositions in determining the problems which scientists address as well as the types of solutions which they find acceptable inevitably led to a dilemma: If scientists are always approaching the world with conceptual frameworks (or if one prefers, paradigms or traditions), then how can discovery take place? If scientists look at the world according to their mental sets, how can they ever see anything new? Moreover, when a discovery is made, what standards determine whether it is acceptable? The appeal to observation and experiment is no longer acceptable as an answer to this question because observation and experiment are themselves conditioned by a conceptual framework. What, then, justifies the claim that one theory is progressive over its predecessor? In brief, the turn away from the positivist emphasis on timeless and universal meanings and structures and toward time-rooted *Weltanschauungen* inevitably led to the problem of scientific progress. The literature on this topic has been voluminous beginning with Hanson (1958), later Kuhn (1970), and most recently Laudan (1977).

This voluminous literature on the problem of scientific progress has not been matched by inquiry into the idea of technological progress. A large literature does exist on effects of technology on society and on economic growth; but this sort of inquiry is very different from investigation into the idea of technological progress.

Just as the issue of scientific progress is closely related to some other significant issues—*i.e.*, the rationality of science and the concept of truth in science—so also the issue of technological progress has significant implications. Perhaps the most important one is the means-use model of technology. This model states that technology is a neutral means; whether it is used for good or evil purposes is not a matter of the nature of technology itself, but rather how man uses it. After examining the problem of technological progress, I shall conclude with a brief discussion of the implications of the position I adopt on this means-use model.

In discussing the idea of technological progress, I shall lay out different models of technological progress. The emphasis shall be on constructing the logical possibilities, rather than on a historical survey of positions which have actually been taken on the progress of technology. However, as a touchstone for assembling and analyzing various logical possibilities, I shall frequently discuss some of the most important historical theories.

Before beginning this inquiry, it will be helpful to engage in a brief analysis of the idea of progress. Van Doren (1967), in his exhaustive study of the idea of progress, suggests that the core residue of meaning which can be extracted from writings on progress includes at least three ideas: (1) a pattern of change; (2) which is, in the long run, irreversible; and (3) which is directed toward an advance in value, toward that which is better (Van Doren, 1967:3). Progress is a pattern of change, but it is more than that. It is change in the direction of improvement. In addition, a theory of progress need not claim that progress is change which is always moving in a straight line toward improvement. Obviously, such a requirement would rule out progress in anything. Progress, rather, is change which is moving in one direction, toward betterment, for the most part and over the long run.

Finally, a note is in order on the classificatory scheme which I shall use in this paper. Models of technological and scientific change seem to fall into two general groupings: cognitive and non-cognitive. The tag "normative" might be used instead of non-cognitive, but I have avoided this because some might claim, and I would tend to agree with them, that cognitive theories also contain many normative elements.

Cognitive models are those which claim that technology is progressing because in some way it is growing in knowledge. In this category, I shall discuss two models: cumulative and problem-solving. Non-cognitive models are those which claim that technology is progressing because it is moving toward some normative goal. There appear to be two principal types of non-cognitive models: the material well-being model, and the moral and spiritual well-being model.

COGNITIVE MODELS OF TECHNOLOGICAL PROGRESS

1. The Cumulative Model

The theory of technological progress which has the greatest weight of tradition behind it is the cumulative model. This theory has its roots in the cumulative theory of scientific progress, and, accordingly, we shall first examine that version of the theory. We shall then turn to technology and explore the possibility of applying the model to that area.

The classic defense of the cumulative model of scientific progress was offered by Francis Bacon (*in* Warhaft, 1965). He argued that for the first time in history it was possible for knowledge to march steadily toward unlocking the secrets of nature. What was the basis of this claim? The key for Bacon was method:

> There are and can be only two ways of searching into and discovering truth. The one flies from the senses and particulars to the most general axioms. . . . And this way is now in fashion. The other derives axioms from the senses and particulars, rising by a gradual and unbroken ascent, so that it arrives at the most general axioms last of all. This is the true way, but as yet untried (Bacon, *in* Warhaft, 1965:333).

Bacon went on, of course, and elaborated considerably on this idea of a reformed, inductive method. But his great idea was that he had discovered *the* scientific method, and that if this method is applied carefully and consistently, it will guarantee the progress of scientific knowledge—*i.e.*, the movement of knowledge toward the truth.

Some of the sharpest statements on the cumulative theory of scientific progress were made by the nineteenth century American Pragmatist, Charles Sanders Peirce, and his statement of the theory may serve as a summary of the position (*in* Hartshorne and Weiss, 1935:23).

> Science is to mean for us a mode of life whose single animating purpose is to *find out the real truth,* which pursues this purpose by a well-considered method, founded on *thorough acquaintance with such scientific results already ascertained* by others as may be available, and which seeks cooperation in the hope that the truth may be found, if not by any of the actual inquirers, yet ultimately by those who come after them and who shall make use of their results.

And in a marvelously vivid metaphor, Peirce (*in* Hartshorne and Weiss, 1935:4) summarizes this idea:

> The idea of science is to pile the ground before the foot of the outworks of truth with the carcasses of this generation and perhaps others to come after it, until some future generation, by treading on them, can storm the citadel.

In sum, the essentials of the cumulative theory of scientific progress are the following. Scientific knowledge is steadily moving toward the truth, or an increasing approximation of reality, and it is doing so because of scientific method. Man has been accumulating knowledge for centuries, but only since the Scientific Revolution of the sixteenth and seventeenth centuries has mankind discovered the proper method for investigating nature. Scrupulous use of this method shall lead to a steady and irreversible uncovering of the secrets of nature. What is significant about this theory for our purposes is that it is an internal theory of progress. It is internal in two respects. First, the essence of science is a method, which if used properly, will move knowledge toward an increasing understanding of the physical world. This increased understanding, or if one prefers, truth, is the second internal aspect of this theory of progress. It suggests that it is part of the very meaning of science to move toward *truth*, in the sense of the way things really are.

While the cumulative theory of scientific progress continues to be defended widely, it is not without problems. The weakest plank in the Baconian and Enlightenment notion of scientific progress is the almost unquestioning faith in method. For Bacon and many of the other defenders of this theory, scientific method was conceived in almost purely mechanical terms. Data are collected, and hypotheses extrapolated from the data are then tested by observation and experiment. The belief was that if the rules were followed properly, truth would be nearly guaranteed. The criticisms of this conception of scientific method are well known and need not be repeated here. It will suffice to note that Bacon and the other defenders of this conception of method underestimated the illogical character of the origin of scientific hypotheses. Hypotheses, the *sine qua non* of scientific inquiry, cannot be cranked out in some mechanical fashion. They seem to require insight or creative imagination which is ultimately not reducible to rational analysis or to a set of logical rules. But we may grant that a more sophisticated theory of method could be compatible with the cumulative theory of scientific progress.

In addition to the problem of method, there are also the perennial epistemological critiques of the cumulative view. These critiques center on the concept of truth and reality and ask a cluster of vexing questions: How can we know whether science is approaching the truth? If truth is taken in the sense of the way things really are, how can we ever know this dimension of reality? Are we in contact only with our experiences of reality? This is not the place to take up these classical philosophical questions. But I would like to defend briefly the soundness of the notion that science is a quest for and a movement toward truth, since this claim will be central to my conclusion to this section.

The history of science indicates that many, and perhaps even most, of the discoveries in science sooner or later find practical application. In fact, Jonas (1976:15-17) argued that this has become increasingly the case in the twentieth century. The only exceptions to this phenomenon seem to be theories of cosmogony (*e.g.*, the big-bang) and some areas of particle physics. This suggests that if a scientific theory is at least partially true, it has at least some capacity to generate technological or other concrete applications. Conversely, if some scientific principle is found to result in useful technology, then in some aspect or another it embodies a truth about the world (Quay, 1974:160). In brief, the fact that a body of scientific knowledge has concrete applications is one of the tests of the truth of that knowledge. Thus, there does seem to be some basis for claiming that scientific knowledge is moving toward truth.

We shall now turn to the central question for our purposes: Can the cumulative model of scientific progress, or some modified version of it, be applied to technology? At first glance, it would appear that it is nonsensical to talk about technology as moving toward an increasing understanding of the physical world, or of moving toward the truth. This would appear to be a fundamental difference between scientific and technological progress. Scientific progress is at least in some sense, as we just argued, a progressive movement toward a greater understanding of the physical world. Technology, by contrast, is not directed toward truth or understanding the world. Technology deals with the world of created devices and techniques, and these do not have to "fit" reality, except in the trivial sense that they cannot disobey the laws of nature (*e.g.*, the technologist cannot build a rocket which travels faster than the speed of light). If there is any sense of truth in technology, it is Vico's notion of *verum factum*—man can have certain knowledge of his creations because he has made them. But this notion of truth, unless one is an unvarnished idealist, is very different from the notion of truth in science. Thus, at first look, it does not appear that there is technological progress in the sense of a step-by-step movement toward the truth.

But the situation is a bit more complicated than this. The history of science and technology is filled with instances of technological devices aiding in science's quest for unravelling the secrets of nature. The most famous example of this is Galileo's use of the telescope to make new astronomical discoveries and to defend Copernicanism (albeit very indirectly). The electron microscope is an example of a technological device which is based on scientific theory but which has also contributed to the development of new theory. Shall we conclude, then, that there is cumulative technological progress insofar as technology contributes to the movement toward truth? This conclusion would be too sweeping. First, this notion of technological progress is too limited in scope, for it applies only to those technologies which have actually led to new discoveries in science. But in the history of technology, most technologies prior to the twentieth century were developed independently of science and had little if any influence on the development of science. For example, cheesemaking, brewing, and metal-making were developed long before the Scientific Revolution of the sixteenth and seventeenth centuries and had no apparent influence on that revolution. Thus, we may conclude that some technologies have sometimes aided science in its quest for an understanding of the universe. But even here, the progress is not really technological progress toward truth as much as it is scientific progress with the aid of technology. Science is frequently parasitic with respect to technology. In conclusion, there is no basis for claiming that technology progresses in the sense that it moves toward the truth.

But is there, then, some other notion of the cumulative theory of technological progress? There are three remaining possibilities: the quantitative increase of technology over time, the increase in the power of technology, and the building of one technology on another. In regard to the first possibility, there has been an obvious increase in the number of technological devices and techniques in the West since approximately the sixth century. This movement began with the stirrup, rotation of crops, the Saxon wheeled-plough, the horse collar, and the crank, and moved on in the nineteenth and twentieth centuries to the steam-engine, telephone, camera, electric lights, nuclear power-plants, and on and on. The number of technological devices has probably been increasing exponentially since the Industrial Revolution.

But this increase is not only quantitative. It is also—and this is the second remaining possibility—marked by a dramatic increase in man's power over nature. Jonas (1974:13) regarded the power which twentieth-century technology has given man as so great that it has transformed human nature. Modern technology, he argued, has created a "new type of human action," one larger and more powerful than ever before.

The third remaining possibility for a cumulative theory of technological progress is the notion that many technological inventions are based on preceding technological devices or processes. The history of technology is filled with illustrations of this phenomenon. One brief case history constructed from Cardwell (1972:66-69) and Pacey (1974:120-129) will suffice to demonstrate this point. In 1661, the German Otto von Guericke constructed a device using a vertically-aligned piston and cylinder to lift weights. Air was pumped out of the cylinder causing the piston, under the force of atmospheric pressure, to descend and to lift the weights. In 1673, Christian Huygens and Denis Papin added a charge of gunpowder to von Guericke's piston. Papin later refined this machine further by using condensed steam to create a vacuum in the cylinder. Finally, Thomas Newcomen and John Cawley took the idea of the cylinder and piston which von Guericke, Huygens, and Papin had developed, plus Papin's idea of creating a vacuum by the condensation of steam, and added a mechanism for turning valves on and off in the right sequence. Here is a clear case, then, of the development of a technology by the building up of one invention on another.

Now is there any basis for claiming that any or all of these types of accumulation—quantitative, in power, and building up—are progressive? A few examples will illustrate that the answer must be negative. Many large and complex technological devices and techniques—large and complex in size, power, and the degree to which they are built up on simpler technologies—have brought with them effects which are generally regarded as regressive. The airplane, rockets, and conventional and atomic bombs have dramatically increased man's ability to wage devastating wars. The factory system has dehumanized labor. Nuclear-power reactors have generated large amounts of wastes which are difficult to dispose of safely. Technology has also, admittedly, dramatically improved the human condition in many ways. But the point of these examples is this: The cumulative movement of technology—whether quantitative, in power, or in building up—does not contain any *intrinsic* measure of progress. From the cumulative point of view, whether technology is progressive or regressive is a matter of extrinsic value choices.

2. The Problem-Solving Model

In a recent work, Laudan (1977) developed an elaborate theory of scientific progress which he called a "problem-solving model." Following our procedure in the previous section, we shall examine Laudan's theory of scientific progress and then investigate whether this model might be applicable to technology.

Laudan failed to offer a definition of what he meant by a problem. Here he would have been well-advised to consult Peirce's classic essay "The Fixation of Belief." Peirce (*in* Hartshorne and Weiss, 1934:230) argued that all inquiry begins with "an uneasy and dissatisfied state from which we struggle to free ourselves." This psychological notion of uneasiness and dissatisfaction may be taken as a good definition of a problem.

To return to Laudan's model, he took as his central claim that "science as a problem-solving system [is] . . . what is most characteristic about science . . . ; the aim of science . . . is the resolution and clarification of problems . . ." (Laudan, 1977:12). To emphasize the unorthodox nature of this claim, Laudan contrasted this position with the usual view that the empirical scientist is primarily interested in "explaining" the world of empirical facts. He argued that scientific theories are not attempts to give high-order explanations of laws and facts, but rather to provide solutions to problems. Not only did Laudan wish to debunk the importance of facts in science, he also played down the importance of the role of "confirmation" and the notion of "truth" in science.

> In appraising the merits of theories, it is more important to ask whether they constitute adequate solutions to significant problems than it is to ask whether they are "true," "corroborated," "well confirmed," or otherwise justifiable within the framework of contemporary epistemology (Laudan, 1977:12).

In determining whether a theory solves a problem, and whether it is, accordingly, acceptable, Laudan claimed that "it is irrelevant whether the theory is true or false, well or poorly confirmed . . . (Laudan, 1977:22-23). And further, ". . . scientists generally do not consider matters of truth and falsity when determining whether a theory does or does not solve a particular empirical problem" (Laudan, 1977:24). Although Laudan's critique of the orthodox notions of confirmation and truth in science is based primarily on historical grounds, he could not resist mentioning the traditional epistemological difficulties with these notions:

> We apparently do not have any way of knowing for sure . . . that science is true, or probable, or that it is getting closer to the truth. Such aims are *utopian*, in the literal sense that we can never know whether they are being achieved (Laudan, 1977:127).

The essential units of science, on Laudan's account, are "research traditions." A research tradition is a "set of assumptions: assumptions about the basic kinds of entities in the world, assumptions about how those entities interact, assumptions about the proper methods to use for construction and testing theories about these entities" (Laudan, 1977:97). Examples of research traditions are Aristotelianism, Cartesianism, Darwinism, Newtonianism, mechanistic biology, and Freudian psychology. It should be emphasized that what are ordinarily called scientific theories–*e.g.,* Aristotle's theory of astronomy, or molecular genetics–are, on Laudan's account, components of research traditions. A research tradition may be composed of multiple theories plus a methodology, experimentation, and even metaphysics. The main point for our purposes is that, according to Laudan, research traditions are the frameworks used to attack problems, and they are also the problem-solutions.

Now what is progress within Laudan's theory of science? Progress can occur on two levels: within research traditions or between them. Progress within a research tradition is simply any change in a theory, law, method, or experiment which solves or comes closer to solving a problem within the tradition. To put the matter briefly and bluntly, progress is any change which is in the direction of the solution of a problem. But what about the relationship between research traditions? Is there any way of knowing whether the replacement of one research tradition by another is progressive? Laudan argued that because of their generality and because of their normative elements, research traditions are not directly testable (Laudan, 1977:81-82). But one research tradition is better than another and thus is progressive if it "leads, via its component theories, to the adequate solution of an increasing range of empirical and conceptual problems" (Laudan, 1977:82). But Laudan emphasized again that such problem-solving success tells us nothing about whether the tradition is "confirmed" or "refuted," or "true" or "false" (Laudan, 1977:82).

Before examining whether this model fits technological progress, a few critical comments are in order. First, Laudan's devaluation (he carefully noted that he was not totally rejecting the concepts) of the notions of confirmation and truth do not seem to be carried through consistently even in his own elaboration of the model. Thus, for example, Laudan stated that one theory is better than another if its predictions are "tested," and if some of them are "borne out in our observation" (Laudan, 1977:67). Again, he argued that theories are components of research traditions, and the successful test of a theory is at the same time at least a partial test of the "adequacy" of a research tradition (Laudan, 1977:82). But what does Laudan mean by checking predictions and making observations unless some sort of encounter with reality? One need not be a naive realist to accept that there is some sort of reality out there which is pressing against our ideas and constantly checking and directing them, albeit the linkage between our ideas and reality may be very indirect. My point is, in brief, that in the end I do not believe that Laudan can escape using reality and truth as criteria for evaluating theories and research traditions, and by that fact progress.

Laudan's assertion that the aim of science is problem-solving is also inadequate. Even if we grant that much or most of science is concerned with problem-solving, this is at most the immediate end of science. We may still ask: Problem-solving for what? Are scientists simply interested in resolving the immediate puzzles at hand and nothing more? Why are they even interested and motivated to seek solutions to problems? The orthodox position on the ends of science seems still to stand: The ultimate or highest goals of science are: (1) either the desire to understand the world, or (2) the desire to gain control over the world for the sake of improving the human condition. Granted, the aim of understanding the world may be an ideal limit which can never be attained. Nevertheless, it does play a central role in scientific inquiry. Laudan seems to deny that there are any "higher" or long-range motives behind the activity of the scientist.

The problem-solving model of progress may, in fact, fit technology much better than science. Investigation of this possibility will be our next task. If we use Peirce's notion of a problem as an "uneasiness" or an "irritation" of the mind, then technological inquiry does indeed seem to begin in this fashion. A case history will be useful for illustrating this claim and for testing the applicability of the problem-solving model to technology in general.

In 1712, Thomas Newcomen built a steam engine that combined for the first time a piston-in-cylinder and a motive principle which involved the formation of a vacuum within the cylinder through the induced condensation of steam (Usher, 1962:347-357; Sherer, 1965). In the winter of 1763-1764, James Watt, while repairing a model of the Newcomen engine, was perplexed by the large amount of steam it used (Usher, 1962:353). Usher, a historian of technology, termed this perplexity the first stage in the process of invention. He called it the "perception of a problem," and defined a problem as an "incomplete or unsatisfactory pattern," or "an unfulfilled want" (Usher, 1962:65).

Returning to the steam engine case-history, further investigation led Watt to realize that the inefficiency of the engine was caused by two conflicting requirements: To utilize steam efficiently, the cylinder had to be kept at 100 C; but to form a vacuum for the power stroke, the cylinder had to be cooled below 100 C (Sherer:167). Usher (1962:65) called this the second stage in the act of invention: "setting the stage."

In 1765, Watt suddenly had insight to solve the problem: He would condense the engine's steam in a separate condensing container to which it would be drawn (Sherer, 1965: 170). This is the third stage, the sudden and dramatic "act of insight," which seems to be so essential to creativity, whether in the arts, sciences, or technology. We may also call this stage, from the viewpoint of the problem-solving model, the solution to the problem. It is not a complete solution because much mopping-up work always remains at this stage. In fact, to return to Watt's invention, Watt spent fifteen years (1765 to 1780) before he completed the development of his new engine (Sherer, 1965:176). He built, tested, modified, and retested models of increasing scale and sophistication. Usher (1962:65) called this last stage "critical revision."

We may now add some other observations on the application of Laudan's problem-solving model to technology. Laudan's claim that confirmation and truth play an insignificant role in science seems to be much more true of technology than of science. In technology, the question is not whether the idea is confirmed or refuted, but whether it can be carried out in practice. There is a type of testing here, but it is not the testing of an idea against given-reality, but rather of the idea against the made-reality, the artifact. Again, in technology, the question is never whether a technological device or process is true or false, but rather whether it fulfills the goals for which it was devised. As noted earlier, Vico's formula *verum factum* applies perfectly to technological devices and processes. If we employ the correspondence theory of truth, then we may say that a technological artifact is true not because it conforms to reality, but because it conforms to the idea in the inventor's mind. Truth is made by man. But, of course we are using truth here in a rather extended sense, and we may prefer simply to state that truth and falsity have no place in technology.

We may conclude at this point that technology comes closer than science to Laudan's problem-solving model. But the critical question remains: Is the problem-solving model a sound theory of technological progress? The answer will not be unequivocal and will require a distinction introduced by Laudan (referred to above). Laudan made a distinction between (1) progress within a problem, and (2) progress in the movement from one problem-solution to another (he referred to research traditions). It does seem sound to assert that there is technological progress in the first sense. There is progress as the inventor moves from awareness of a problem to its resolution through creation of a technological device or process. Thus, here progress is simply movement in the direction of the solution of a *specific* problem.

There are some distinct advantages of such a theory of technological progress. First, it has the value of concreteness and precision. There is always something vague and troubling about the notion of technology progressing toward truth, or the material and spiritual well-being of mankind. Secondly, the theory seems to be an intrinsic theory of progress. If problem-solving is of the very essence of technology, then there is a notion of progress internal to technology—namely, the movement toward the solution of a problem.

But when all is said and done, this notion of technological progress is very emaciated. When we speak of technological progress in modern discourse, we are usually referring to long-term improvement of some sort. Can we say, under the problem-solving model, that technology is moving toward some sort of betterment as it moves from one problem-solution to another problem-solution? In short, is there any way of determining whether technology progresses between problem-solutions? Laudan (1977:78), speaking of scientific progress, solved the problem of determining whether there is progress between problem-solutions by appealing to such criteria as the internal consistency of the theories within one research tradition compared to the consistency of those within a competing research tradition, the degree of generality of the problem, the age of the problem, and the number of problems which a theory solves. But none of these criteria appears to be applicable to technological devices and processes. In technology, the fact that one problem-solution is regarded as more significant than another seems to be a matter of historical circumstance and cultural and personal choices. Thus, the fact that the development of solar energy is regarded as a significant problem in the United States today is because of the depletion of our domestic reserves of oil and our high degree of dependence on foreign oil. But these causes can be pushed back another stage. Our need for oil at all is a result of our dependence on the automobile, modern air travel, elaborate industrial machinery, and so on. Similarly, the reason the atomic bomb was regarded as important in 1944 was because it offered a solution to the prolongation of the war. The alternative of bombing by conventional means and invading Japan did not appear attractive after five years of warfare. On the basis of the problem-solving model, therefore, there is nothing in the structure of technology which can serve as a basis for claiming that the movement of technology from one problem-solution to another problem-solution is progressive. The only way to evaluate whether there is such a progression is by an appeal to extrinsic goals or values.

In sum, the problem-solving model does have this value: It allows us to say that there is progress within a specific field (or subfield) within relatively short periods of time—that is, in the movement from the awareness of a problem to its solution. But when we ask the broader question, "Is technology progressing?" the problem-solving model seems to be of little help. The model does not contain any internal criterion for determining whether there is progress when we move from one problem-solution to another problem-solution.

NON-COGNITIVE MODELS OF TECHNOLOGICAL PROGRESS

On the basis of our examination of the cumulative and problem-solving models, we may draw the general conclusion that the important question is not whether technology advances either in the cumulative sense or in the problem-solving sense. The crucial question is whether technology advances for the better—*i.e.,* whether it is progressive. Is man's accumulation of technical devices and procedures and his piling up of problem-solutions an advance toward betterment? We concluded that there is nothing in the internal structure of technology which can serve as a basis for claiming that technology is progressive, except in the very limited sense of the movement toward the solution of a specific problem.

We shall now turn to non-cognitive theories of technological progress—*i.e.,* theories which do not define progress in terms of an increase in knowledge. Traditionally, two general non-cognitive goals of technology have been defended: an improvement in the material well-being of man, and an improvement in the moral and spiritual well-being of man.

1. Material Well-being

Bacon is again the *locus classicus* for this model. We have already observed that Bacon claimed that his age was witnessing a new power to unravel the secrets of nature, and this new power was a consequence of the new scientific method (actually, a reformed inductive method). And one of the ends of this new scientific and technological knowledge was "the endowment of human life with new inventions and riches" (*in* Warhaft, 1965:354).

Bacon's position is a very general form of the material well-being model. This model can be given more specific form, and one of the most popular variants of the position links scarcity, technology, and man's material well-being. Edward Bellamy's *Looking Backward 2000-1887* (*in* Elliott, 1966) presents a classic statement of this argument. Bellamy constructs a technocratic utopia in which the planning, production, and distribution of goods is accomplished by an elaborate social and economic machine. Bellamy's utopia is technological not only in the sense that it is a society filled with gadgets and machines, but also in the extended sense that the society is based on a high degree of rational organization in the name of efficiency. The organization of society is like a large machine in which personnel are components. Bellamy (*in* Elliott, 1966:170) has Dr. Leete, one of the principal characters in the novel, compare the older order to the new: The *ancien régime,* Leete observes, may be likened to "the military efficiency of a mob, or a horde of barbarians with a thousand petty chiefs, as compared with that of a disciplined army under one general—such a fighting machine, for example, as the German army in the time of Von Moltke." Julian West, the narrator of the novel, agrees with this analogy. In a nightmare in which he dreams that he had returned to the old order, he observes (*in* Elliott, 1966:194) a military parade, and reflects that "here at last were order and reason, an exhibition of what intelligent cooperation can accomplish." He sees the passing regiment not as individuals, but as a "tremendous engine . . . able to vanquish a mob ten times as numerous." And he asks himself why the citizens of the old order "fail to compare the scientific manner in which the nation went to war with the unscientific manner in which it went to work?"

This new production machine will, according to Bellamy (*in* Elliott, 1966), virtually abolish scarcity. Over the entrance to the distribution center—a huge department-store-like institution—stands "a majestic life-size group of statuary, the central figure of which was a female ideal of Plenty, with her cornucopia" (p. 194). Dr. Leete (p. 112) observes that "as regards the great staples of life, of which an abundance can always be secured, scarcity is eliminated as a factor. There is always a great surplus kept on hand from which any fluctuations of demand or supply can be corrected, even in most cases of bad crops." And it is clear that in Bellamy's scheme this abundance is a result of the great technological machine of production.

This construction of a chain between technology, scarcity, and progress has many weak links. First, technology is only one of a network of factors which are necessary to reduce scarcity. The way the economic, social, and political system distributes goods is also a primary factor in ameliorating man's material estate. And we have no basis for claiming that this ensemble of factors is moving, over the long run, toward the material improvement of the human condition.

But a second difficulty is even more telling. One of the phenomena of modern technology is the power to expand man's wants constantly. Galbraith (1958, 1967, 1974) has argued tirelessly that modern capitalism, through mass advertising (a type of technology), is able both to manipulate and expand human wants continually. And we might add that it is also technology in the form of mass production which makes possible the satisfaction of each new level of wants.

But is there any basis for claiming that this continual creation and satisfaction of wants is progressive? Galbraith (1967) points out that many wants which are created and satisfied are trivial and goods while "public goods" go unmet. Technological, capitalist economies produce videotape machines, synthetic foods, and recreation vehicles, while public transportation, housing, and the environment suffer. At this point it might be objected that to call synthetic foods *trivial goods* and public transportation *public goods* is to beg the question. This assumes a hierarchy of wants, and this involves a value judgment. What is ultimately at issue is the question of what constitutes the Good Life, and it is obviously beyond our scope here to discuss this question. But perhaps we can circumvent this perennial question by making a distinction between types of needs and wants.

The basic cut that seems to be required in any discussion of wants and needs is between basic biological needs and non-biological or conditioned wants and needs. The former are the basic requirements for physical survival—food, minimal shelter, and perhaps companionship. The latter are all those needs which are a product of one's particular society and culture. The class of non-biological wants and needs can be further subdivided into subsistence needs and luxurious needs. Subsistence needs are those which must be fulfilled to live a minimally decent life in a specific society. These will obviously vary greatly from society to society. A minimally decent life in the United States is drastically different from a minimally decent life in Rwanda, eastern Africa. All needs beyond subsistence may be classified as luxurious needs—albeit some luxurious needs (*e.g.,* a color television in the United States) will be much closer to subsistence needs than others (*e.g.,* a Mercedes Benz in the United States) (*see* Gendron, 1977: 216-219).

The relevance of this discussion to the question of the role of technology in progress toward material well-being is the following. We may say minimally that technology has been progressive with respect to playing a crucial role in potentially fulfilling man's basic needs. Admittedly, millions of people in the world are still undernourished and suffering from curable diseases; but these are caused by the other part of that ensemble which we mentioned above, and not by the nature of deficiencies of technology. Technology because of its power over nature has the ability to fulfill man's basic needs, and the desirability of filling basic biological needs seems to be beyond question even by the most skeptical ethicians.

But whether technology is progressive in fulfilling man's non-biological needs and wants is entirely dependent on value judgments. It is at this point that the critics of technology bring in their lists of social ills caused either directly or indirectly by technology—pollution, compulsive consumption, resource depletion, alienated work, mass advertising, and so on. It is beyond our present purposes to discuss these so-called "negative effects" of technology. The conclusion that may be drawn is that the determination of whether technology is progressive with respect to man's material well-being is, as soon as we leave the area of basic biological needs, a matter of a value judgment, and such judgment is extrinsic to technology. But technology is *potentially* and *intrinsically*—because of its power to manipulate nature—progressive with respect to fulfilling man's basic biological needs.

2. Moral and Spiritual Well-being Models

If the modern age can no longer say with assurance that technology is steadily and irreversibly increasing man's material well-being, then is there any sense in which it can say that technology is increasing man's moral and spiritual well-being? A common Enlightenment theory of moral and spiritual progress through science and technology was one which linked science and technology to knowledge of moral, social, and economic truths. Diderot (*in* Passmore, 1970:205) capsulized this position in his famous statement that "we are criminals only because we judge wrongly."

There are some classic difficulties with this position. Even if one holds a rationalistic ethic (what we ought to do is what is reasonable), it does not follow that we will be good. Reason may tell us what we ought to do, but what we actually do is another matter. The mistake of the Enlightenment authors is not their linking of reason and virtue, but rather the necessity which they claim is present between the two—the assertion that if we see what is reasonable we *will* do it.

A more modern variant of the moral and spiritual well-being model is the position which draws a connection between scarcity, technology, and moral and spiritual well-being. We saw an attempt to draw such a linkage in our discussion of the material well-being model. A similar argument is frequently applied to moral and spiritual well-being. Bellamy (*in* Elliott, 1966) may be taken as one source of this position. In addition to the already-mentioned argument that technology would bring about a material cornucopia, Bellamy also argued that technology's ability to overcome scarcity will bring with it the promise of a just society. Julian West, the main character in Bellamy's *Looking Backward* states regarding the new order:

> The nation is rich and does not wish the people to deprive themselves of any good thing. In your day, men were bound to lay up goods and money against coming failure of the means of support and for their children. This necessity made parsimony a virtue. But now it would have no such laudable object, and, having lost its utility, it has ceased to be regarded as a virtue. No man any more has any care for the morrow, either for himself or his children, for the nation guarantees the nature, education, and comfortable maintenance of every citizen from the cradle to the grave (*in* Elliott, 1966:54–55).

In the new order, technology has overcome scarcity, which heretofore was the principal motive for storing up riches. Thus, the new abundance has, for the first time in history, made possible "the equal wealth and equal opportunities of culture which all persons now enjoy . . ." (*in* Elliott, 1966:95).

In fact, Bellamy in a burst of enthusiasm, even expanded this argument to include other virtues.

> In your day [West argues, speaking about the old order] fully nineteen twentieths of the crime, using the word broadly to include all sorts of misdemeanors, resulted from the inequality in the possessions of individuals; want tempted the poor, lust of greater gains, or the desire to preserve former gains, tempted the well-to-do. Directly or indirectly, the desire for money, which then meant every good thing, was the motive of all this crime, the taproot of a vast poison growth . . . (*in* Elliott, 1966:122).

But the new order "cut this root" by "abolishing want" and "checking the accumulation of riches" (*in* Elliott, 1966:122). And, of course, the abolishing of want was accomplished by technology. In brief, the abolition of want through technology was largely, although not entirely, responsible for abolishing most crime and bringing about a just social order.

In addition to ushering in a virtuous society, Bellamy argued that technology can help man develop his "higher" faculties—what we might call man's spiritual well-being. Because of the technological, social machine (described in the preceding section), members of the new order may retire at forty-five so that they "can fully devote [themselves] to the higher exercise of [their] faculties, the intellectual and spiritual enjoyments and pursuits which alone mean life" (*in* Elliott, 1966:118).

There are several standard objections to this position, but we need note only two. First, only a few seem to be capable of the enjoyment of "higher" pleasures. In fact, many persons, perhaps even the majority, have no interest in pursuing the cultivation of scholarly and artistic pursuits. Should such persons simply be dismissed as less fully developed persons than the few who do enjoy the higher pleasures? Secondly, the experience of Western societies in recent decades points to the ***naîveté*** of Bellamy's claim that scarcity is the source of most social ills. Western Europe, Japan, the United States, and Canada have achieved a level of abundance which is almost utopian and yet social ills remain and seem even to worsen.

Whether we agree or disagree with the arguments of Diderot and Bellamy, the main point that I would like to draw from the survey of these two theories of moral and spiritual progress through technology is that the theories depend upon extrinsic goals. The production of material abundance, the creation of a just society, and the cultivation of man's higher faculties are all goals outside of the structure of technology. Thus, whether technological change is interpreted as progress in the direction of the moral and spiritual betterment of mankind is a matter of the values chosen by an individual or ascribed to by a society.

CONCLUSION

In closing, I wish to examine briefly the implication of this study of the idea of technological progress on the means-use model of technology. This model states that technology is a neutral means; whether it is used for good or evil purposes is not a matter of the nature of technology itself, but rather of how man uses it. This model is immensely popular. Schumacher (1973:156) assumed it when he called for a change in the direction of technology: "[We] are deeply convinced that technological development has taken a wrong turn and needs to be redirected." Similarly, Pacey (1974:309) stated that "the problem [with technology] . . . is to define new directions for technical progress in which there is a promise for the future—to decide on objectives for scientific and technological development which carry more conviction than many existing ones." The continuing popularity of this means-use model is indicated by two recent studies of the history of technology. Cardwell (1972:223) stated that

> It is not technology that threatens our society and its values. For technology is itself a distinctive and dependent offspring of the philosophy, cosmology, and religion of that society. Technology is a highly refined instrument, although like all instruments it may be mis-applied.

And Pacey (1974:309) argued that "the crucial point is that the direction of progress [Pacey is referring primarily to technological progress] is always a matter of choice."

The means-use model has an unsettlingly facile and simplistic ring to it. Is the movement of technology simply a matter of man's choice? Is technology always a means or only sometimes? Does technology contain a direction which is, at least to some degree, outside of the control of man? If it does, then the means-use model, at least in its pure form, is invalid. Finally, we may ask a further question: If technology does contain an internal direction, then is this direction progressive—*i.e.,* is it moving toward betterment?

We saw that for the most part our answer to both the question concerning intrinsic direction and the question of whether this direction is progressive was negative. Since there is no intrinsic direction to technology, the cumulative model cannot be applied to technology. The problem-solving model of technology seems to be valid for the immediate, short-term solution of a problem, but it cannot be applied to the long-run movement of technology. The material well-being model does seem to work for the potential fulfillment of man's basic biological needs, but it fails once we move beyond these needs. Finally, there is nothing in the nature of technology which moves technology inexorably toward man's moral and spiritual improvement.

Our analysis of technological progress suggests, then, that the means-use model of technology is essentially valid. There does not appear to be any internal direction to technology, much less any internal direction which is progressive—except for the minimal senses of short-term moving toward the solution of a problem and the promise of fulfilling man's basic biological needs.

But we have examined the means-use model only from the viewpoint of logical analysis of models of technological progress. There are, of course, other perspectives from which the means-use model can be viewed. Perhaps one of the most important is with respect to the degree that technology plays a role in human life. Let us briefly examine where this approach might lead.

A strong case can be made, I believe, for the thesis that in earlier times the means-use model was an accurate description of man's relation to technology, but that this model is becoming increasingly inaccurate, especially with the advent of large-scale technological systems. Collingwood (1945:8) has noted that machines did not play a central role in the lives of the Greeks and Romans:

> The Greeks and Romans were not machine users except to a very small extent; their catapults and water-clocks were not a prominent enough feature of their lives to affect the way in which they conceived the relation between themselves and the world.

But with the Renaissance, technology began to play a greater role in man's life (Collingwood, 1945:9):

> The Renaissance view of nature . . . (is partly) . . . based on the human experience of designing and constructing machines. . . . By the sixteenth century . . . the printing press and the windmill, the pump and the pulley, the clock . . . were established features of daily life. Everyone understood the nature of a machine. . . .

Finally, Winner (1977) argued that the contemporary world has witnessed another quantum jump in the development of technology—the jump to large-scale technological systems. Such systems are "networks of highly advanced development—systems characterized by a large size, concentration, extension, and the complex interconnection of a great number of artificial and human parts" (Winner, 1977:238). These systems, in contrast to earlier technologies, "do not respond positively to human guidance" (Winner, 1977:227). "Beyond a certain level of technological development, the rule of freely-articulated, strongly-asserted purposes is a luxury that can no longer be permitted" (Winner, 1977:238). Winner formulated a new phrase to describe the dynamics of large-scale technological systems—"reverse adaption," and he described (Winner, 1977:227) this phenomenon as follows:

> The goals, purposes, needs, and decisions that are supposed to determine what technologies do are in important instances no longer the true source of their direction. Technical systems become severed from the ends originally set for them, and, in effect, reprogram themselves and their environment to suit the special conditions of their own operation. The artificial slave gradually subverts the rule of the master.

Winner offered this theory as an alternative to the theory espoused by Mills (1956) and Galbraith (1967), among others, that technical elites are the real rulers in a technological society. Winner argued, by contrast, that large-scale technological systems take on a life of their own, and that human ends are forced to conform to these ends. He offered numerous illustrations of this phenomenon, and I shall cite only a few. First, in large, technically-oriented societies, people "come to accept the *norms* and *standards* of technical processes as central to their lives as a whole" (Winner, 1977:229, italics mine). Efficiency, for example, is no longer applied only to the office or assembly line, but to pleasure, leisure, learning, and reading (witness the popularity of speed-reading courses). Another illustration of the autonomy of large-scale technical systems is the tendency for these systems to develop new missions after the original mission for which the system was developed has been fulfilled. The technological tool is not retired. Rather, the system may "take direct action to extend its control over the ends themselves" (Winner, 1977:241). For example, NASA has flown men to the moon. What shall it do now? The agency has proposed many new projects: the space shuttle; exploration of Mars, Venus, and Jupiter; and asteriod space-colonies. The argument frequently used to support the continuation of NASA is that such a magnificent aerospace team should not be dismantled.

In sum, the line of argument here is that technologies in earlier times were responsive to man's control. But with the introduction of large-scale technologies, this is no longer the case. Winner argued further that originally all technologies are purposive, even large-scale technological systems. Large-scale systems come into existence as a result of conscious decisions by men. But the control of these systems by man tends to decrease as the systems grow and as they become a more integral part of human life.

This position is consistent with the general conclusion which we drew from our logical analysis of models of technological progress. We argued that technology does not contain any inherent direction; the direction of technology, and by that fact also its progressiveness, are contingent on man's choices. This offers at least some grounds for being optimistic about the future direction of technology.

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