How Technology Will Shape the Future

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There are two ways, at least, to approach an understanding of how technology will affect the future. One, which I do not adopt here, is to try to predict the most likely technological developments of the future along with their most likely social effects (*1*). The other way is to identify some respects in which technology entails change and to suggest the kinds or patterns of change that, by its nature, it brings about in society. It is along the latter lines that I speculate in what follows, restricting myself largely to the contemporary American scene.

New Technology Means Change

It is widely and ritually repeated these days that a technological world is a world of change. To the extent that this statement is meaningful at all, it would seem to be true only of a world characterized by a more or less continuous development of new technologies. There is no inherent impetus toward change in tools as such, no matter how many or how sophisticated they may be. When new tools emerge and displace older ones, however, there is a strong presumption that there will be changes in nature and in society.

I see no such necessity in the technology-culture or technology-society relationship as we associate with the Marxist tradition, according to which changes in the technology of production are inevitably and univocally determinative of culture and social structure. But I do see, in David Hume's words, a rather "constant conjunction" between technological change and social change as well as a number of good reasons why there should be one, after we discount for the differential time lags that characterize particular cases of social change consequent on the introduction of new technologies.

The traditional Marxist position has been thought of as asserting a strict or hard determinism. By contrast, I would defend a position that William James once called a "soft" determinism, although he used the phrase in a different context. (One may also call it a *probabilistic* determinism and thus avoid the trap of strict causation.) I would hold that the development and adoption of new technologies make for changes in social organization and values by virtue of creating new possibilities for human action and thus altering the mix of options available to men. They may not do so necessarily, but I suggest they do so frequently and with a very high probability.

Technology Creates New Possibilities

One of the most obvious characteristics of new technology is that it brings about or inhibits changes in *physical* nature, including changes in the patterns of physical objects or processes. By virtue of enhancing our ability to measure and predict, moreover, technology can, more specifically, lead to controlled or directed change. Thus, the plow changes the texture of the soil in a specifiable way; the wheel speeds up the mobility (change in relative position) of people or objects; and the smokebox (or icebox) inhibits some processes of decay. It would be equally accurate to say that these technologies respectively *make possible* changes in soil texture, speed of transport, and so forth.

In these terms, we can define any new (nontrivial) technological change as one which (i) makes possible a new way of inducing a physical change; or (ii) creates a wholly new physical possibility that simply did not exist before. A better mousetrap or faster airplane are examples of new ways and the Salk vaccine or the moon-rocket are instances of new possibilities. Either kind of technological change will extend the range of what man *can* do, which is what technology is all about.

There is nothing in the nature or fact of a new tool, of course, that requires its use. As Lynn White has observed, "a new device merely opens a door; it does not compel one to enter" (*2*). I would add, however, that a newly opened door does *invite* one to enter (*3*). A house in which a number of new doors have been installed is different from what it was before and the behavior of its inhabitants is very likely to change as a result. Possibility as such does not imply actuality (as a strict determinism would have to hold), but there is a high probability of realization of new possibilities that have been deliberately created by technological development, and therefore of change consequent on that realization.

Technology Alters the Mix of Choices

A correlative way in which new technology makes for change is by removing some options previously available. This consequence of technology is derivative, indirect, and more difficult to anticipate than the generation of new options. It is derivative in that old options are removed only after technology has created new ones. It is indirect, analogously, because the removal of options is not the result of the new technology, but of the act of choosing the new options that the technology has created (*4*). It is more difficult to anticipate, finally, to the degree that the positive consequences *for* which a technology is developed and applied are seen as part of the process of decision to develop and apply, whereas other (often negative) consequences of the development are usually seen only later if at all.

Examples abound. Widespread introduction of modern plumbing can contribute to convenience and to public health, but it also destroys the kind of society that we associate with the village pump. Exploitation of industrial technology removes many of the options and values peculiar to an agricultural society. The automobile and airplane provide mobility, but often at the expense of

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stabilities and constancies that mobility can disturb.

Opportunity costs are involved in exploiting any opportunity, in other words, and therefore also the opportunities newly created by technology. Insofar as the new options are chosen and the new possibilities are exploited, older possibilities are displaced and older options are precluded or prior choices are reversed. The presumption, albeit not the necessity, that most of the new options will be chosen is therefore at the same time a presumption that the choice will be made to pay the new costs. Thus, whereas technology begins by simply adding to the options available to man, it ends by altering the spectrum of his options and the mix or hierarchy of his social choices.

Social Change

The first-order effect of technology is thus to multiply and diversify material possibilities and thereby offer new and altered opportunities to man. Different societies committed to different values can react differently (positively or negatively, or simply differently) to the same new possibilities, of course. This is part of the explanation, I believe, for the phenomenon currently being referred to as the "technological gap" between Western Europe and the United States. Moreover, as with all opportunities when badly handled, the ones created by technology can turn into new opportunities to make mistakes. None of this alters the fact that technology creates opportunity.

Since new possibilities and new opportunities generally require new organizations of human effort to realize and exploit them, technology generally has second-order effects that take the form of social change. There have been instances in which changes in technology and in the material culture of a society have not been accompanied by social change, but such cases are rare and exceptional (*5*). More generally:

> . . . over the millennia cultures in different environments have changed tremendously, and these changes are basically traceable to new adaptations required by changing technology and productive arrangements. Despite occasional cultural barriers, the useful arts have spread extremely widely, and the instances in which they have not been accepted because of pre-existing cultural patterns are insignificant (*6*).

While social change does not necessarily follow upon technological change, it almost always does in fact, thus encouraging the presumption that it generally will. The role of the heavy plow in the organization of rural society and that of the stirrup in the rise of feudalism provide fascinating medieval examples of a nearly direct technology-society relationship (*7*). The classic case in our era, of course—which it was Karl Marx's contribution to see so clearly, however badly he clouded his perception and blinded many of his disciples by tying it at once to a rigid determinism and to a form of Hegelian absolutism—is the Industrial Revolution, whose social effects continue to proliferate.

When social change does result from the introduction of a new technology, it must, at least in some of its aspects, be of a sort conducive to exploitation of the new opportunities or possibilities created by that technology. Otherwise it makes no sense even to speak of the social effects of technological change. Social consequences need not be and surely are not uniquely and univocally determined by the character of innovation, but they cannot be entirely independent of that character and still be accounted consequences. (Therein lies the distinction, ultimately, between a hard and soft determinism.) What the advent of nuclear weapons altered was the military organization of the country, not the structure of its communications industry, and the launching of satellites affects international relations much more directly than it does the institutions of organized sport. (A change in international relations may affect international competition in sports, of course, but while everything may be connected with everything else in the last analysis, it is not so in the first.)

There is a congruence between technology and its social effects that serves as intellectual ground for all inquiry into the technology-society relationship. This congruence has two aspects. First, the subset of social changes that can result from a given technological innovation is smaller than the set of all possible social changes and the changes that do in fact result are a still smaller subset of those that can result—that is, they are a sub-subset. In relation to any given innovation, the spectrum of all possible social changes can be divided into those that cannot follow as consequences, those that can (are made possible by the new technology), and those that do (the actual consequences).

It is the congruence of technology and its social consequences in this sense that provides the theoretical warrant for the currently fashionable art of "futurology." The more responsible practitioners of this art insist that they do not predict unique future events but rather identify and assess the likelihood of possible future events or situations. The effort is warranted by the twin facts that technology constantly alters the mix of possibilities and that any given technological change may have several consequences.

The second aspect of the congruence between technology and its social consequences is a certain "one-wayness" about the relationship—that is, the determinative element in it, however "soft." It is after all only technology that creates new *physical* possibilities (though it is not technology *alone* that does so, since science, knowledge, social organization, and other factors are also necessary to the process). To be sure, what technologies will be developed at any particular time is dependent on the social institutions and values that prevail at that particular time. I do not depreciate the interaction between technology and society, especially in our society which is learning to create scientific knowledge to order and develop new technologies for already established purposes. Nevertheless, once a new technology is created, it is the impetus for the social and institutional changes that follow it. This is especially so since a social decision to develop a particular technology is made in the principal expectation of its predicted first-order effects, whereas evaluation of the technology after it is developed and in operation usually takes account also of its less-foreseeable second- and even third-order effects.

The "one-wayness" of the technology-society relationship that I am seeking to identify may be evoked by allusion to the game of dice. The initiative for throwing the dice lies with the player, but the "social" consequences that follow the throw are initiated *by the dice* and depend on how the dice fall. Similarly, the initiative for development of technology in any given instance lies with people, acting individually or as a public, deliberately or in response to such pressures as wars or revolutions. But the material initiative remains with the technology and the social adaptation to it remains its consequence. Where the

analogy is weak, the point is strengthened. For the rules of the game remain the same no matter how the dice fall, but technology has the effect of adding new faces to the dice, thus inducing changes in society's rules so that it can take advantage of the new combinations that are created thereby. That is why new technology generally means change in society as well as in nature.

Technology and Values

New technology also means a high probability of change in individual and social values, because it alters the conditions of choice. It is often customary to distinguish rather sharply between individual and social values and, in another dimension, between tastes or preferences, which are usually taken to be relatively short-term, trivial, and localized, and values, which are seen as higher-level, relatively long-term, and extensive in scope. However useful for some purposes, these distinctions have no standing in logic, as Kenneth Arrow points out:

> One might want to reserve the term "values" for a specially elevated or noble set of choices. Perhaps choices in general might be referred to as "tastes." We do not ordinarily think of the preference for additional bread over additional beer as being a value worthy of philosophic inquiry. I believe, though, that the distinction cannot be made logically . . . (*8*).

The *logical* equivalence of preferences and values, whether individual or social, derives from the fact that all of them are rooted in choice behavior. If values be taken in the contemporary American sociologist's sense of broad dominant commitments that account for the cohesion of a society and the maintenance of its identity through time, their relation to choice can be seen both in their genesis (historically in the society, not psychologically in the individual) and in their exemplification (where they function as criteria for choice).

Since values in this sense are rather high-level abstractions, it is unlikely that technological change can be seen to influence them directly. We need, rather, to explore what difference technology makes for the choice behaviors that the values are abstractions from.

What we choose, whether individually or as a society (in whatever sense a society may be said to choose, by public action or by resultant of private actions) is limited, at any given time, by the options available. (Preferences and values are in this respect different from aspirations or ideals in that the latter can attach to imaginative constructs. To confuse the two is to confuse morality and fantasy.) When we say that technology makes possible what was not possible before, we say that we now have more options to choose from than we did before. Our old value clusters, whose hierarchical ordering was determined in the sense of being delimited by antecedent conditions of material possibility, are thus now subject to change because technology has altered the material conditions.

By making available new options, new technology can, and generally will, lead to a restructuring of the hierarchy of values, either by providing the means for bringing previously unattainable ideals within the realm of choice and therefore of realizable values, or by altering the relative ease with which different values can be implemented—that is, by changing the costs associated with realizing them. Thus, the economic affluence that technological advance can bring may enhance the values we associate with leisure at the relative expense of the value of work and achievement, and the development of pain-killing and pleasure-producing drugs can make the value of material comfort relatively easier of achievement than the values we associate with maintaining a stiff upper lip during pain or adversity.

One may argue further that technological change leads to value change of a particular sort in exact analogy to the subset of possible social changes that a new technology may augur (as distinct from both the wider set that includes the impossible and the narrower, actual subset). There are two reasons for this. First, certain attitudes and values are more conducive than others to most effective exploitation of the potentialities of new tools or technologies. Choice behavior must be somehow attuned to the new options that technology creates, so that they will in fact be chosen. Thus, to transfer or adapt industrial technologies to underdeveloped nations is only part of the problem of economic development; the more important part consists in altering value predispositions and attitudes so that the technologies can flourish. In more advanced societies, such as ours, people who hold values well adapted to exploitation of major new technologies will tend to grow rich and occupy elite positions in society, thus serving to reinforce those same values in the society at large.

Second, whereas technological choices will be made according to the values prevailing in society at any given time, those choices will, as previously noted, be based on the foreseeable consequences of the new technology. The essence of technology as creative of new possibility, however, means that there is an irreducible element of uncertainty—of unforeseeable consequence—in any innovation (*9*). Techniques of the class of systems analysis are designed to anticipate as much of this uncertainty as possible, but it is in the nature of the case that they can never be more than partially successful, partly because a new technology will enter into interaction with a growing number and variety of ongoing processes as societies become more complex, and partly—at least in democratic societies—because the unforeseeable consequences of technological innovation may take the form of negative *political* reaction by certain groups in the society.

Since there is an irreducible element of uncertainty that attends every case of technological innovation, therefore, there is need for two evaluations: one before and one after the innovation. The first is an evaluation of prospects (of ends-in-view, as John Dewey called them). The second is an evaluation of results (of outcomes actually attained) (*10*). The uncertainty inherent in technological innovation means there will usually be a difference between the results of these two evaluations. To that extent, new technology will lead to value change.

Contemporary Patterns of Change

Our own age is characterized by a deliberate fostering of technological change and, in general, by the growing social role of knowledge. "Every society now lives by innovation and growth; and it is theoretical knowledge that has become the matrix of innovation" (*11*, p. 29; *12*).

In a modern industralized society, particularly, there are a number of pressures that conspire toward this result. First, economic pressures argue for the greater efficiency implicit in a new technology. The principal example of this is the continuing process of capital modernization in industry. Second, there are political pressures that seek the greater absolute effectiveness of a new technology, as in

our latest weapons, for example. Third, we turn more and more to the promise of new technology for help in dealing with our social problems. Fourth, there is the spur to action inherent in the mere availability of a technology: space vehicles spawn moon programs. Finally, political and industrial interests engaged in developing a new technology have the vested interest and powerful means needed to urge its adoption and widespread use irrespective of social utility.

If this social drive to develop ever more new technology is taken in conjunction with the very high probability that new technology will result in physical, social, and value changes, we have the conditions for a world whose defining characteristic is change, the kind of world I once described as Heraclitean, after the pre-Socratic philosopher Heraclitus, who saw change as the essence of being (*13*).

When change becomes that pervasive in the world, it must color the ways in which we understand, organize, and evaluate the world. The sheer fact of change will have an impact on our sensibilities and ideas, our institutions and practices, our politics and values. Most of these have to date developed on the assumption that stability is more characteristic of the world than change—that is, that change is but a temporary perturbation of stability or a transition to a new (and presumed better or higher) stable state. What happens to them when that fundamental metaphysical assumption is undermined? The answer is implicit in a number of intellectual, social, and political trends in present-day American society.

Intellectual Trends

I have already noted the growing social role of knowledge (*14*). Our society values the production and inculcation of knowledge more than ever before, as is evidenced by sharply rising research, development, and education expenditures over the last 20 years. There is an increasing devotion, too, to the systematic use of information in public and private decision-making, as is exemplified by the President's Council of Economic Advisers, by various scientific advisory groups in and out of government, by the growing number of research and analysis organizations, by increasing appeal to such techniques as program planning and budgeting, and by the recent concern with assembling and analyzing a set of "social indicators" to help gauge the social health of the nation (*15*).

A changing society must put a relatively strong accent on knowledge in order to offset the unfamiliarity and uncertainty that change implies. Traditional ways (beliefs, institutions, procedures, attitudes) may be adequate for dealing with the existent and known. But new technology can be generated and assimilated only if there is technical knowledge about its operation and capabilities, and economic, sociological, and political knowledge about the society into which it will be introduced.

This argues, in turn, for the importance of the social sciences. It is by now reasonably well established that policy-making in many areas can be effective only if it takes account of the findings and potentialities of the natural sciences and of their associated technologies. Starting with economics, we are gradually coming to a similar recognition of the importance of the social sciences to public policy. Research and education in the social sciences are being increasingly supported by public funds, as the natural sciences have been by the military services and the National Science Foundation for the last quarter of a century. Also, both policy-makers and social scientists are seeking new mechanisms of cooperation and are exploring the modifications these will require in their respective assumptions and procedures. This trend toward more applied social science is likely to be noticeable in any highly innovative society.

The scientific mores of such a society will also be influenced by the interest in applying technology that defines it. Inquiry is likely to be motivated by and focused on problems of the society rather than centering mainly around the unsolved puzzles of the scientific disciplines themselves. This does not mean, although it can, if vigilance against political interference is relaxed, (i) that the resulting science will be any less pure than that proceeding from disinterested curiosity, or (ii) that there cannot therefore be any science motivated by curiosity, or (iii) that the advancement of scientific knowledge may not be dependent on there always being some. The research into the atomic structure of matter that is undertaken in the interest of developing new materials for supersonic flight is no less basic or pure than the same research undertaken in pursuit of a new and intriguing particle, even though the research strategy may be different in the two cases. Even more to the point, social research into voting behavior is not *ipso facto* less basic or pure because it is paid for by an aspiring candidate rather than by a foundation grant.

There is a serious question, in any event, about just how pure is pure in scientific research. One need not subscribe to such an out-and-out Marxism as Hessen's postulation of exclusively social and economic origins for Newton's research interests, for example, in order to recognize "the demonstrable fact that the thematics of science in seventeenth century England were in large part determined by the social structure of the time" (*16*). Nor should we ignore the fashions in science, such as the strong emphasis on physics in recent years that was triggered by the military interest in physics-based technologies, or the very similar present-day passion for computers and computer science. An innovative society is one in which there is a strong interest in bringing the best available knowledge to bear on ameliorating society's problems and on taking advantage of its opportunities. It is not surprising that scientific objectives and choices in that society should be in large measure determined by what those problems and opportunities are, which does not mean, however, that scientific objectives are identical with or must remain tied to social objectives.

Another way in which a society of change influences its patterns of inquiry is by putting a premium on the formulation of new questions and, in general, on the synthetic aspects of knowing. Such a society is by description one that probes at scientific and intellectual frontiers, and a scientific frontier, according to the biologist C. H. Waddington, is where "we encounter problems about which we cannot yet ask sensible questions" (*17*). When change is prevalent, in other words, we are frequently in the position of not knowing just what we need to know. A goodly portion of the society's intellectual effort must then be devoted to formulating new research questions or reformulating old ones in the light of changed circumstances and needs so that inquiry can remain pertinent to the social problems that knowledge can alleviate.

Three consequences follow. First, there is a need to reexamine the knowledge already available for its meaning in the context of the new questions. This is the synthetic aspect of knowing. Sec-

ond, the need to formulate new questions coupled with the problem-orientation, as distinct from the discipline-orientation, discussed above requires that answers be sought from the intersection of several disciplines. This is the impetus for current emphases on the importance of interdisciplinary or cross-disciplinary inquiry as a supplement to the academic research aimed at expanding knowledge and training scientists. Third, there is a need for further institutionalization of the function of transferring scientific knowledge to social use. This process, which began in the late 19th century with the creation of large central research laboratories in the chemical, electrical, and communications industries, now sees universities spawning problem- or area-oriented institutes, which surely augur eventual organizational change, and new policy-oriented research organizations arising at the borderlines of industry, government, and universities, and in a new no-man's land between the public and private sectors of our society.

A fundamental intellectual implication of a world of change is the greater theoretical utility of the concept of process over that of structure in sociological and cultural analysis. Equilibrium theories of various sorts imply ascription of greater reality to stable sociocultural patterns than to social change. But as the anthropologist Evon Vogt argues,

> change is basic in social and cultural systems . . . Leach [E. R.] is fundamentally correct when he states that "every real society is a process in time." Our problem becomes one of describing, conceptualizing, and explaining a set of ongoing processes . . . ,

but none of the current approaches is satisfactory "in providing a set of conceptual tools for the description and analysis of the *changing* social and cultural *systems* that we observe" (*18*).

There is no denial of structure: "Once the processes are understood, the structures manifested at given time-points will emerge with even greater clarity," and Vogt goes on to distinguish between short-run "recurrent processes" and long-range and cumulative "directional processes." The former are the repetitive "structural dynamics" of a society. The latter "involve alterations in the structures of social and cultural systems" (*18*, pp. 20–22). It is clear that the latter, for Vogt, are more revelatory of the essence of culture and society as changing (*19*).

Social Trends

Heraclitus' philosophy of universal change was a generalization from his observation of physical nature, as is evident from his appeal to the four elements of ancient physics (fire, earth, water, and air) in support of it (*20*, p. 37, fragments 28 to 34). Yet he offered it as a metaphysical generalization. Change, flux, is the essential characteristic of all of existence, not of matter only. We should expect to find it central also, therefore, to societies, institutions, values, population patterns, and personal careers.

We do. Among the effects of technological change that we are beginning to understand fairly well even now are those (i) on our principal institutions: industry, government, universities; (ii) on our production processes and occupational patterns; and (iii) on our social and individual environment: our values, educational requirements, group affiliations, physical locations, and personal identities. All of these are in movement. Most are also in process; that is, there is direction or pattern to the changes they are undergoing, and the direction is moreover recognizable as a consequence of the growing social role of knowledge induced by proliferation of new technology.

It used to be that industry, government, and universities operated almost independently of one another. They no longer do, because technical knowledge is increasingly necessary to the successful operation of industry and government, and because universities, as the principal sources and repositories of knowledge, find that they are adding a dimension of social service to their traditional roles of research and teaching. This conclusion is supported (i) by the growing importance of research, development, and systematic planning in industry; (ii) by the proliferation and growth of knowledge-based industries; (iii) by the changing role of the executive, who increasingly performs sifting, rearranging, and decision operations on ideas that are generated and come to him from below; (iv) by the entry of technical experts into policy-making at all levels of government; (v) by the increasing dependence of effective government on availability of information and analysis of data; (vi) by the importance of education and training to successful entry into the society and to maintenance of economic growth; and (vii) by the growth, not only of problem-oriented activities on university campuses, but also of the social role (as consultants, advisory boards, and so forth) of university faculties.

The economic affluence that is generated by modern industrial technology accelerates such institutional mixing-up by blurring the heretofore relatively clear distinction between the private and public sectors of society. Some societies, like the Scandinavian, can put a strong emphasis on the acquisition of public or social goods even in the absence of a highly productive economy. In our society, affluence is a precondition of such an emphasis. Thus, as we dispose increasingly of resources not required for production of traditional consumer goods and services, they tend to be devoted to providing such public goods as education, urban improvement, clean air, and so forth.

What is more, goods and services once considered private more and more move into the public sector, as in scientific research and graduate education or the delivery of medical care. As we thus "socialize" an increasing number of goods once considered private, however, we tend also to farm out their procurement to private institutions, through such devices as government grants and contracts. As a result,

> . . . our national policy assumes that a great deal of our new enterprise is likely to follow from technological developments financed by the government and directed in response to government policy; and many of our most dynamic industries are largely or entirely dependent on doing business with the government through a subordinate relationship that has little resemblance to the traditional market economy (*21*).

Another observer says:

> Increasingly it will be recognized that the mature corporation, as it develops, becomes part of the larger administrative complex associated with the state. In time the line between the two will disappear (*22*).

This fluidity of institutions and social sectors is not unreminiscent of the more literal fluidity that Heraclitus immortalized: "You cannot step twice into the same river, for other waters are continually flowing on" (*20*, p. 29, fragment 21). But also like the waters of a river, the institutional changes of a technologically active age are not aimless; they have direction, as noted, toward an enhancement of the use of knowledge in society:

> Perhaps it is not too much to say that if the business firm was the key institution

of the past hundred years, because of its role in organizing production for the mass creation of products, the university will become the central institution of the next hundred years because of its role as the new (*sic*) source of innovation and knowledge (*11*, p. 30).

One should recall, in this connection, that the university is the portal which more and more people enter into productive roles in society and that it increasingly provides the training necessary for leadership in business and government as well as in education.

The considerable debate of the last few years about the implications of technological change for employment and the character of work has not been in vain. Positions originally so extreme as to be untenable have been tempered in the process. Few serious students of the subject believe any longer that the progress of mechanization and automation in industry must lead to an irreversible increase in the level of *involuntary* unemployment in the society, whether in the form of unavailability of employment, or of a shortening work week, or of lengthening vacations, or of an extension of the period of formal schooling. These developments may occur, either voluntarily, because people choose to take some of their increased productivity in the form of leisure, or as a result of inadequate education, poor social management, or failure to ameliorate our race problem. But reduction of the overall level of employment is not a necessary consequence of new industrial technology.

Too much is beginning to be known about what the effects of technology on work and employment in fact are, on the other hand, for them to be adequately dealt with as merely transitional disruptions consequent on industrialization. A number of economists are therefore beginning to move away from explanation in terms of transition (which is typical of traditional equilibrium theory) to multi-level "steady state" models, or to dynamic theories of one sort or another, as more adequate to capturing the reality of constant change in the economy (*23*).

The fact is that technological development has provided substitutes for human muscle power and mechanical skills for most of history. Developments in electronic computers are providing mechanical substitutes for at least some human mental operations. No technology as yet promises to duplicate human creativity, especially in the artistic sense, if only because we do not yet understand the conditions and functioning of creativity. (This is not to deny that computers can be useful aids to creative activity.) Nor are there in the offing mechanical equivalents for the initiatives inherent in human emotions, although emotions can of course be affected and modified by drugs or electrical means. For the foreseeable future, therefore, one may hazard the prediction that distinctively human work will be less and less of the "muscle and elementary mental" kind, and more and more of the "intellectual, artistic, and emotional" kind. (This need *not* mean that only highly inventive or artistic people will be employable in the future. There is much sympathy needed in the world, for example, and the provision of it is neither mechanizable nor requisite of genius. It is illustrative of what I think of as an "emotional" service.)

While advancing technology may not displace people by reducing employment in the aggregate, therefore, it unquestionably displaces some jobs by rendering them more efficiently performed by machines than by people. There devolves on the society, as a result, a major responsibility for inventing and adopting mechanisms and procedures of occupational innovation. These may range from financial and organizational innovations for diverting resources to neglected public needs to social policies which no longer treat human labor as a market commodity. Whatever the form of solution, however, the problem is more than a "transitional" one. It represents a qualitative and permanent alteration in the nature of human society consequent on perception of the ubiquity of change.

This perception and the anticipatory attitude that it implies have some additional consequences, which are not less important but are as yet less well understood even than those for institutional change and occupational patterns. For example, lifetime constancy of trade or profession has been a basis of personal identity and of the sense of individuality. Other bases for this same sense have been identification over time with a particular social group or set of groups as well as with physical or geographical location.

All of these are now subject to Heraclitean flux. The incidence of life-long careers will inevitably lessen, as employing institutions and job contents both change. More than one career per lifetime is likely to be the norm henceforth. Group identities will shift as a result: every occupational change will involve the individual with new professional colleagues, and will often mean a sundering from old friends and cultivation of new ones. Increasing geographical mobility (already so characteristic of advanced industrial society) will not only reinforce these impermanencies, but also shake the sense of identity traditionally associated with ownership and residence upon a piece of land. Even the family will lose influence as a bastion of personality, as its loss of economic *raison d'être* is supplemented by a weakening of its educational and socializing functions and even of its prestige as the unit of reproduction (*24*).

I have alluded elsewhere to the implications for education of a world seen as essentially changing (*13*). Education has traditionally had the function of preparing youth to assume full membership in society (i) by imparting a sense for the history and accumulated knowledge of the race, (ii) by imbuing the young with a sense of the culture, mores, practices, and values of the group, and (iii) by teaching a skill or set of skills necessary to a productive social role. Philosophies of education have accordingly been elaborated on the assumption of stability of values and mores, and on the up-to-now demonstrable principle that one good set of skills well learned could serve a man through a productive lifetime.

This principle is undermined by contemporary and foreseeable occupational trends, and the burden of my general argument similarly disputes the assumption of unalterable cultural stabilities. There are significant implications for the enterprise of education. They include, (i) a decline in the importance of manual skills, (ii) a consequent rising emphasis on general techniques of analysis and evaluation of alternatives, (iii) training in occupational flexibility, (iv) development of management skills, and (v) instruction in the potentialities and use of modern intellectual tools. The major problem of contemporary education at the primary and secondary levels is that the educational establishment is by and large unprepared, unequipped, and poorly organized to provide education consonant with these realities.

Above all, perhaps, higher education especially will need to attend more deliberately and systematically than it has in recent decades to developing the reflective, synthetic, speculative, and even the contemplative capacities of men, for understanding may be at a relatively greater premium henceforth than particular knowledge. When we can no longer

lean on the world's stabilities, we must be able to rely on new abilities to cope with change and be comfortable with it.

There is an analogous implication for social values and for the human enterprise of valuing. There is concern expressed in many quarters these days about the threat of technology to values. Some writers go so far as to assert an incompatibility between technology and values and to warn that technological progress is tantamount to dehumanization and the destruction of all value (*25*).

There is no question, as noted earlier, that technological change alters the mix of choices available to man and that choices made ipso facto preclude other choices that might have been made. Some values are destroyed in this process, which can thus involve punishing traumata of adjustment that it would be immoral to ignore. It is also unquestionably the case that some of the choices made are constrained by the very technology that makes them available. In such cases, the loss of value can be tragic, and justly regretted and inveighed against. It is in the hope of anticipating such developments that we are currently investigating means to assess and control technological development in the public interest.

On the other hand, I find no justification for the contention that technological progress must of necessity mean a progressive destruction of value. Such fears seem rather to be based partly on psychological resistance to change and partly on a currently fashionable literary mythology that interprets as a loss the fact that the average man today does not share the values that were characteristic of some tiny elites centuries ago. To the extent that it is more than that, this contention is based, I think, on a fundamental misunderstanding of the nature of value.

The values of a society change more slowly, to be sure, than the realities of human experience; their persistence is inherent in their emergence as values in the first place and in their function as criteria, which means that their adequacy will tend to be judged later rather than earlier. But values do change, as a glance at any history will show. They change more quickly, moreover, the more quickly or extensively a society develops and introduces new technology. Since technological change is so prominent a characteristic of our own society, we tend to note inadequacies in our received values more quickly than might have been the case in other times. When that perception is coupled with the conviction of some that technology and value are inherently inimical to each other, the opinion is reinforced that the advance of technology must mean the decline of value and of the amenities of distinctively human civilization.

While particular values may vary with particular times and particular societies, however, the activity of valuing and the social function of values do not change. That is the source of the stability so necessary to human moral experience. It is not to be found, nor should it be sought, exclusively in the familiar values of the past. As the world and society are seen increasingly as processes in constant change under the impact of new technology, value analysis will have to concentrate on process, too: on the process of valuation in the individual and on the process of value formation and value change in the society. The emphasis will have to shift, in other words, from values to valu*ing*. For it is not particular familiar values as such that are valuable, but the human ability to extract values from experience and to use and cherish them. And that value is not threatened by technology; it is only challenged by it to remain adequate to human experience by guiding us in the reformulation of our ends to fit our new means and opportunities.

Political Trends

There are a number of respects in which technological change and the intellectual and social changes it brings with it are likely to alter the conditions and patterns of government. I construe government in this connection in the broadest possible sense of the term, as governance (with a small "g") of a *polity*. Better yet, I take the word as equivalent to govern*ing*, since the participle helps to banish both visions of statism and connotations of public officialdom. What I seek to encompass by the term, in other words, is the social decision-making function in general, whether exemplified by small or large or public or private groups. I include in decision-making, moreover, both the values and criteria that govern it and the institutions, mechanisms, procedures, and information by means of which it operates.

One notes that, as in other social sectors and institutions, the changes that technology purports for government are of a determinate sort—they have direction: they enhance the role of government in society and they enhance the role of knowledge in government.

The importance of decision-making will tend to grow relative to other social functions (relative to production, for example, in an affluent society): (i) partly because the frequency with which new possibilities are created in a technologically active age will provide many opportunities for new choices, (ii) partly because continuing alteration of the spectrum of available choice alternatives will shorten the useful life of decisions previously made, (iii) partly because decisions in areas previously thought to be unrelated are increasingly found to impinge on and alter each other, and (iv) partly because the economic affluence consequent on new technology will increase the scope of deliberate public decision-making at the expense, relatively, of the largely automatic and private charting of society's course by market forces. It is characteristic of our time that the market is increasingly distrusted as a goal-setting mechanism for society, although there is of course no question of its effectiveness as a signaling and controlling device for the formulation of economic policy.

Some of the ways in which knowledge increasingly enters the fabric of government have been amply noted, both above and in what is by now becoming a fairly voluminous literature on various aspects of the relation of science and public policy (*26*). There are other ways, in addition, in which knowledge (information, technology, science) is bound to have fundamental impacts on the structures and processes of decision-making that we as yet know little about.

The newest information-handling equipments and techniques find their way quickly into the agencies of federal and local government and into the operations of industrial organizations, because there are many jobs that they can perform more efficiently than the traditional rows of clerks. But it is notorious that adopting new means in order to better accomplish old ends very often results in the substitution of new ends for old ones (*27*). Computers and associated intellectual tools can thus, for example, make our public decisions more informed, efficient, and rational, and less subject to lethargy, partisanship, and ignorance. Yet that possibility seems to imply a degree of expertise and sophistication of policy-making and implementing procedures that may leave the public forever ill-informed, blur the lines between

executive and legislature (and private bureaucracies) as all increasingly rely on the same experts and sources of information, and chase the idea of federalism into the history books close on the heels of the public-private separation.

There is in general the problem of what happens to traditional relationships between citizens and government, to such prerogatives of the individual as personal privacy, electoral consent, and access to the independent social criticism of the press, and to the ethics of and public controls over a new elite of information keepers, when economic, military, and social policies become increasingly technical, long-range, machine-processed, information-based, and expert-dominated.

An exciting possibility that is however so dimly seen as perhaps to be illusory is that knowledge can widen the area of political consensus. There is no question here of a naive rationalism such as we associate with the 18th-century enlightenment. No amount of reason will ever triumph wholly over irrationality, certainly, nor will vested interest fully yield to love of wisdom. Yet there are some political disputes and disagreements, surely, that derive from ignorance of information bearing on an issue or from lack of the means to analyze fully the probable consequence of alternative courses of action. Is it too much to expect that better knowledge may bring about greater political consensus in such cases as these? Is the democratic tenet that an informed public contributes to the commonweal pure political myth? The sociologist S. M. Lipset suggests not:

> Insofar as most organized participants in the political struggle accept the authority of experts in economics, military affairs, interpretations of the behavior of foreign nations and the like, it becomes increasingly difficult to challenge the views of opponents in moralistic "either/or" terms. Where there is some consensus among the scientific experts on specific issues, these tend to be removed as possible sources of intense controversy (*28*).

Robert E. Lane of Yale has made the point more generally:

> If we employ the term "ideology" to mean a comprehensive, passionately believed, self-activating view of society, usually organized as a social movement . . . it makes sense to think of a domain of knowledge distinguishable from a domain of ideology, despite the extent to which they may overlap. Since knowledge and ideology serve somewhat as functional equivalents in orienting a person toward the problems he must face and the policies he must select, the growth of the domain of knowledge causes it to impinge on the domain of ideology (*12*, p. 660).

Harvey Brooks, finally, draws a similar conclusion from consideration of the extent to which scientific criteria and techniques have found their way into the management of political affairs. He finds an

> increasing relegation of questions which used to be matters of political debate to professional cadres of technicians and experts which function almost independently of the democratic political process. . . . The progress which is achieved, while slower, seems more solid, more irreversible, more capable of enlisting a wide consensus (*29*).

I raise this point as fundamental to the technology-polity relationship, not by way of hazarding a prediction. I ignore neither the possibility that *value* conflicts in political debate may become sharper still as factual differences are muted by better knowledge, nor the fact that decline of political ideology does not *ipso facto* mean a decline of political disagreement, nor the fear of some that the hippie movement, literary anti-intellectualism, and people's fears of genuine dangers implicit in continued technological advance may in fact augur an imminent retreat from rationality and an interlude—perhaps a long interlude—either of political know-nothingism reminiscent of Joseph McCarthy or of social concentration on contemplative or religious values.

Yet, if the technology-values dualism is unwarranted, as I argued above, it is equally plausible to find no more warrant in principle in a sharp separation between knowledge and political action. Like all dualisms, this one too may have had its origins in the analytic abhorrence of uncertainty. (One is reminded in this connection of the radical dualism that Descartes arrived at as a result of his determination to base his philosophy on the only certain and self-evident principle he could discover.) There certainly is painfully much in political history and political experience to render uncertain a positive correlation between knowledge and political consensus. The correlation is not necessarily absent therefore, and to find it and lead society to act on it may be the greatest challenge yet to political inquiry and political action.

To the extent that technological change expands and alters the spectrum of what man can do, it multiplies the choices that society will have to make. These choices will increasingly have to be deliberate social choices, moreover, rather than market reflections of innumerable individual consumer choices, and will therefore have to be made by political means. Since it is unlikely—despite futurists and technological forecasters—that we will soon be able to predict future opportunities (and their attendant opportunity costs) with any significant degree of reliability in detail, it becomes important to investigate the conditions of a political system (I use the term in the wide sense I assigned to "government" above) with the flexibility and value presuppositions necessary to evaluate alternatives and make choices among them as they continue to emerge.

This prescription is analogous, for governance of a changing society, to those advanced above for educational policy and for our approach to the analysis of values. In all three cases, the emphasis shifts from allegiance to the known, stable, formulated, and familiar, to a *posture* of expectation of change and readiness to deal with it. It is this kind of shift, occurring across many elements of society, that is the hallmark of a truly Heraclitean age. It is what Vogt seeks to formalize in stressing processual as against structural analysis of culture and society. The mechanisms, values, attitudes, and procedures called for by a social posture of readiness will be different in kind from those characteristic of a society that sees itself as mature, "arrived," and in stable equilibrium. The most fundamental *political* task of a technological world, in other words, is that of systematizing and institutionalizing the social expectation of the changes that technology will continue to bring about.

I see that task as a precondition of profiting from our accumulating knowledge of the effects of technological change. To understand those effects is an intellectual problem, but to do something about them and profit from the opportunities that technology offers is a political one. We need above all, in other words, to gauge the effects of technology on the *polity*, so that we can derive some social value from our knowledge. This, I suppose, is the 20th-century form of the perennial ideal of wedding wisdom and government.

References and Notes

1. Herman Kahn and his associates at the Hudson Institute have made a major effort in this direction in *Toward the Year 2000: A Framework for Speculation* (Macmillan, New York, 1967).
2. L. White, Jr., *Medieval Technology and*

Social Change (Oxford Galaxy Book, New York, 1966), p. 28.
3. Melvin Kransberg has made this same point in *Virginia Quart. Rev.* **40**, No. 4, 591 (1964).
4. I deal extensively (albeit in a different context) with the making of new possibilities and the preclusion of options by making choices in my *How Language Makes Us Know* (Nijhoff, The Hague, 1964), chap. 3.
5. One such case is described by E. Z. Vogt, *Modern Homesteaders: The Life of a Twentieth-Century Frontier Community* (Harvard Univ. Press, Cambridge, Mass., 1955). The Mennonite sects in the Midwest are another example.
6. J. H. Steward, *Theory of Culture Change: The Methodology of Multi-linear Evolution* (Univ. of Illinois Press, Urbana, 1955), p. 37. Steward is generally critical of such fellow anthropologists as Leslie White and Gordon Childe for adopting strong positions of technological determinism. Yet even Steward says, "White's . . . 'law' that technological development expressed in terms of man's control over energy underlies certain cultural achievements and social changes [has] long been accepted" (p. 18).
7. See L. White, Jr., (*2*, pp. 44 ff. and 28 ff). Note especially White's contention that analysis of the influence of the heavy plow has survived all the severe criticisms leveled against it.
8. K. J. Arrow, "Public and private values," in *Human Values and Economic Policy*, S. Hook, Ed. (New York Univ. Press, New York, 1967), p. 4.
9. R. L. Heilbroner points up this unforeseeable element—he calls it the "indirect effect" of technology—in *The Limits of American Capitalism* (Harper and Row, New York, 1966), p. 97.
10. J. Dewey, *Theory of Valuation*, International Encyclopedia of Unified Science, vol. 2, No. 4 (Univ. of Chicago Press, Chicago, 1939). The model of the ends-means continuum that Dewey developed in this work should prove useful in dealing conceptually with the value changes implicit in new technology.
11. D. Bell, *The Public Interest*, No. 6 (winter 1967). See also R. E. Lane (*12*) for evidence and a discussion of some of the political implications of this development.
12. R. E. Lane, *Amer. Sociol. Rev.* **31**, No. 5, 652 (Oct. 1966).
13. E. G. Mesthene, *Technol. and Cult.* **6**, No. 2, 226 (spring 1965). D. A. Schon also has recently recalled Heraclitus for a similar descriptive purpose and has stressed how thoroughgoing a revolution of attitudes is implied by recognition of the pervasive character of change [*Technology and Change* (Delacorte Press, New York, 1967), p. xi ff.]
14. In addition to Bell and Lane (*11*), see also L. K. Caldwell, *Publ. Admin. Rev.* **27**, No. 3 (June 1967); R. L. Heilbroner, (*9*, pt. 2); and A. F. Westin, *Columbia Law Rev.* **66**, No. 6, 1010 (June 1966).
15. See "Social goals and indicators for American society," *Ann. Amer. Acad. Polit. Soc. Sci.* **1**, **2** (May and September 1967).
16. R. K. Merton, *Social Theory and Social Structure* (Free Press, Glencoe, Ill., 1949), p. 348. Hessen's analysis is in "The Social and Economic Roots of Newton's Mechanics," *Science at the Crossroads* series (Kniga, London, no date). The paper was read at the Second International Congress of the History of Science and Technology, 29 June to 3 July 1931.
17. Quoted in *Graduate Faculties Newsletter* (Columbia University, March 1966).
18. E. Z. Vogt, *Amer. Anthropol.* **62**, 1, 19, 20 (1960).
19. The structure-process dualism also has its familiar philosophical face, of course, which a fuller treatment than this paper allows should not ignore. Such a discussion would recall at least the metaphysical positions that we associate with Aristotle, Hegel, Bergson, and Dewey.
20. P. Wheelwright, *Heraclitus* (Atheneum, New York, 1964). In his commentary on fragments 28 to 34, Wheelwright makes clear that the element of fire which looms so large in Heraclitus remains a physical actuality for him, however much he may also have stressed its symbolic character (pp. 38–39).
21. D. K. Price, *The Scientific Estate* (Harvard Univ. Press, Cambridge, Mass., 1965), p. 15.
22. J. K. Galbraith, *The New Industrial State* (Houghton Mifflin, Boston, 1967), p. 393.
23. I am indebted to conversations with John R. Meyer and to a personal communication from Robert M. Solow for clarification of this point.
24. These points are made and discussed by R. S. Morison, "Where is biology taking us?," in *Scientific Progress and Human Values*, E. and E. Hutchings, Eds. (Elsevier, New York, 1967), p. 121 ff.
25. Examples of such apocalyptic literature are: J. Ellul, *The Technological Society* (Knopf, New York, 1964); D. Michael, *Cybernation: The Silent Conquest* (Center for the Study of Democratic Institutions, Santa Barbara, Calif., 1962); and J. W. Krutch, New York *Times Magazine*, 30 July 1967.
26. See, for example, the sections "Science, politics and government" in L. K. Caldwell, *Science, Technology and Public Policy: A Selected and Annotated Bibliography* (Indiana Univ. Press, Bloomington, 1968).
27. For a more extended discussion, see E. G. Mesthene, *Publ. Admin. Rev.* **27**, No. 2 (June 1967).
28. S. M. Lipset, *Daedalus*, **93**, 273 (1964).
29. H. Brooks, "Scientific concepts and cultural change," in *Science and Culture*, G. Holton, Ed. (Houghton Mifflin, Boston, 1965), p. 71.
30. I thank my colleagues for comments during the preparation of the article, and especially Irene Taviss of the Harvard Program on Technology and Society.

NEWS AND COMMENT

Budget Cuts: Government Agencies Preparing To Reduce Spending

Donald F. Hornig, the President's science adviser, says, "It's not going to be as bad as some expect," but that is the most favorable forecast to be had on the budget-cutting preparations now underway in Washington.

The cuts are required by the newly passed tax bill, which granted the administration's long sought tax increase, but with the proviso that $6 billion be cut from the amount the administration planned to spend in the fiscal year that began 1 July. The bill also requires a $10 billion reduction during this fiscal year in new obligational authority—that is, in commitments to spend, regardless of the year in which the money is actually laid out. But since the new fiscal year is already underway, the pressing matter at this moment is the $6 billion. Just where all the money will come from is not clear, since Congress will account for some of the $6 billion through cuts in appropriations bills; then it is up to the administration to take care of the rest.

To accomplish this, the Bureau of the Budget has directed all federal agencies to draw up plans for reduced spending, though the vital question of how much remains unanswered. But, since the braking system on federal spending is fairly sluggish, Charles J. Zwick, director of the Bureau, directed the agencies, effective 1 July, to hold back on making new commitments until it is determined how much spending each will have to forego.

At the National Science Foundation, whose budget was vigorously chopped by the House several months ago—$500 million was requested and $400 million was voted—preparations for famine were underway prior to the Bureau of the Budget directive. On 26 June, NSF director Leland J. Haworth sent a notice to the heads of grantee institutions, advising them "to start planning for operating within an expenditure limitation." The phrasing of the notice did not make it altogether clear, but NSF officials confirm that, as things are now shaping up, it is likely that NSF grantees may not be permitted to use all the funds that had been allocated for their grants. For example, a grantee who last year was awarded a sum to be expended over a 3-year period may be directed to reduce this year's spending below the level that NSF had originally approved. NSF officials say that if this comes about, it would be the first time in the Foundation's 18-year history that its commitments have not been fully honored.

The Foundation's method for determining the size of the cuts in each grant is likely to have an enlivening effect on faculty politics. Each institution will be told how much to cut from its overall NSF receipts and grant-by-grant cuts will then be worked out within the institution. The National Institutes of Health, on the other hand, has decided to negotiate reductions with