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Are We Going To Rule Our Own Technology– Or Will We Be Ruled By It?

by BRUCE MURRAY

THE IDEAS of science have had a tremendous effect on the human race. Especially in the Western societies, they have eroded man's ties with tradition by undermining the sometimes traditional bases for authority and morality. It is therefore true that, as we go through these difficult centuries — and our children and children's children go through what is obviously going to be some great climax of the human drama — that science must become an integral part of the world view of all human beings. Somehow there will have to be a reconciliation between the feelings of man and the facts of science — a harmonizing of rationality and morality.

It is also true that the handmaiden of science — technology — has completely changed almost every aspect of human and social activity, from birth to death. New technology is needed to help create living patterns that reconcile material needs with the psychological structures all of us inherit and possess. Somehow there must be a harmonizing of body and soul.

It must be apparent that I consider the present to be unprecedented. Man has nearly saturated the surface of this planet, and that transition to saturation is taking place in an extremely brief time. Along with this has come an enormous growth of economic activity, unprecedented interdependency of human beings, and increase in scale of political, economic, and social institutions. There is no precedent in history for this, and many contemporary problems basically derive from our mega-economic, political, and social structure.

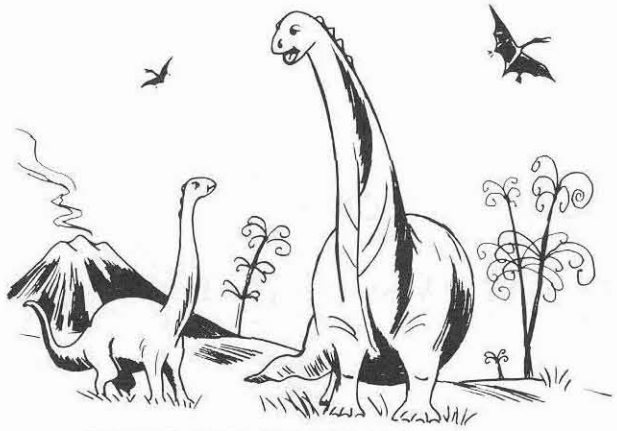
Man the toolmaker still exists (computers, for example, are just very sophisticated tools). But he has constructed more and more elaborate tools — we call it technology — and he has now reached the point where he is either going to be the master or the slave of those tools. But along with this technology has come an ever-increasing division of labor, more specialization — and enormously more interconnectedness.

As the scale of economic enterprises has grown to global proportions, the individual feels more and more isolated. He is in every sense — socially, economically, politically — part of larger and larger structures, and therefore he feels less and less a sense of community. He feels unable to influence his own destiny.

The irony of this fantastic growth — and affluence in the industrialized countries — is that the mighty have become vulnerable to the humble. The wealthiest people in New York are hostage to the vagaries of the teamsters and the garbage collectors. In Socialist countries, where the strike is forbidden by repressive measures, the response is the sullen neglect of quality — passive resistance of a different kind. Furthermore, the rich and the poor, the powerful and the weak, become subject to ever more penetrating governmental interaction, which is deemed necessary to keep the global mega-economic system from breaking down. First comes propaganda in which the citizens are persuaded to believe that what exists is really good and they should be happy and appreciate the opportunities they have. When that doesn't work, repression is used, and if *that* doesn't work, there's even the prospect of behavioral engineering: Change the human being to better fit this mega-economic structure.

Needless to say, this kind of accelerated growth has produced a tremendous reaction against scale — against anything big, whether it's government, economic enterprises, cities, or universities.

There is also a specific reaction against technology because it is perceived that technology is integrally related to these mega structures; therefore it must be somehow responsible. So, if one could simply kill technology by putting a wooden stake through its heart, maybe the rest of the problems would go away.



"LOOK KID, WE'RE AWARE OF THE PROBLEMS BESETTING OUR SOCIETY. WE'RE WORKING ON THEM"

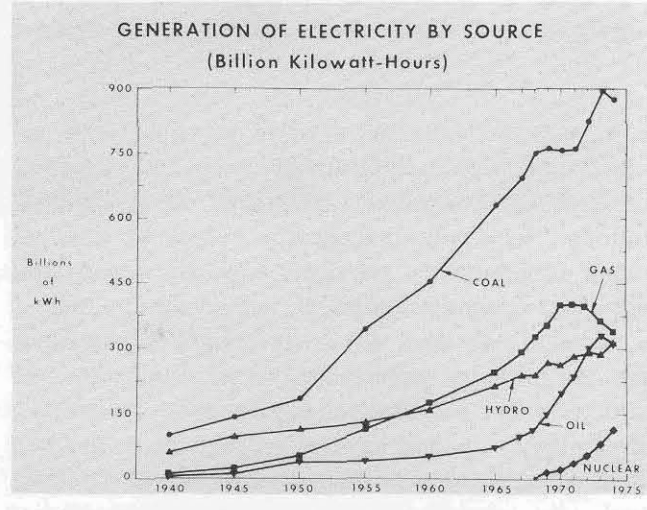
The antiscale attitude bubbled to the surface of national and international consciousness several years ago with a book by an MIT group called *Limits to Growth,* which presents the thesis that there are finite limits to resources and to what environmental burdens can be maintained. Hence, it is argued that the world is in imminent (about 50 years) danger of going into a situation where adequate natural and human resources will not be available. In addition, overpopulation will fatally damage the ability of the planet to sustain itself. The counter argument against this doomsday view is that technology will always come through with a substitute that will take care of the problem. Thus, the debate between the technological optimists and pessimists continues.

Another, and I think more perceptive, attack on scale is a book by E. F. Schumacher called *Small Is Beautiful,* in which he argues most effectively for the benefits of a conscious policy of decentralization and regionalization. I have come to find this view attractive.

Representing a fringe beyond Schumacher is Ivan Illich, a very thoughtful person who has provoked considerable controversy by attacking such institutions as the educational and medical systems in this country, claiming that they are obsolete and no longer serve their original purposes. In his 1973 book, *Tools of Conviviality,* he develops the concept of a "radical monopoly." For example, he points out that in an earlier period, in order to travel between where one lived and worked, one could walk, ride a horse, or take a wagon (if you were rich enough). When cars were first introduced, there was an additional choice as well. Now, if you live in southern California, there is only one choice — the automobile and, usually, the freeway. That is worse than economic monopoly; it is a limitation on ways to live your life. So even though we are richer, and better off in many ways than our grandfathers, we actually have more limited choices of how we do some basic things — including transportation.

Beyond people like Illich, who are attacking the institutional base of the country but still are intellectually credible, there are violent revolutionaries — real anarchists — who have decided that the only way to cope with this enormous problem of scale is to destroy "the system." Incidentally, there's another kind of anarchist — the "establishment anarchist." These are the people who, even though they are political figures, are running against big government. Consider four names from the recent presidential election: Reagan, Carter, Ford, and Brown. They had one thing in common — they all ran against the government! How can a professional politician be against his own institution? But they were. This is a political manifestation of the reaction against scale.

In considering the growth of antitechnology, I can note that, within my professional lifetime, the scientist and engineer has gone from hero to antihero. That's an interesting transition to live through. Congress now has an Office of Technology Assessment, which is a political statement that not all technology is necessarily good, and that we must try to anticipate the consequences of new technology. This pattern was certainly apparent in the debate that developed in the recent election in California over Proposition 15, an initiative to slow down or stop altogether the development of nuclear power. Proposition 15 was novel. It concerned technology, not civil rights. It was negative, because it would have restrained one form of technology (in this



Electrical energy has increased almost tenfold since 1940 — and the principal source of the increase has been from fossil fuels.

case nuclear) without offering alternative means of providing new energy or reducing the demand for it. The fact that it lost is irrelevant; that it was such a political issue is significant.

Will there be a change? Will there be a shift away from the path we seem to be on? I would argue, yes. Not just because people sense the need for it, but because the large-scale economic system we have is built upon shifting shoals — the shoals of cheap oil. Cheap oil is going to run out, and that is going to drive us away from the overcentralized mega-economic society.

Since 1940 in this country there has been an increase of almost tenfold in the use of electrical energy. The principal source of this increase has been the combustion of oil especially to run power plants.

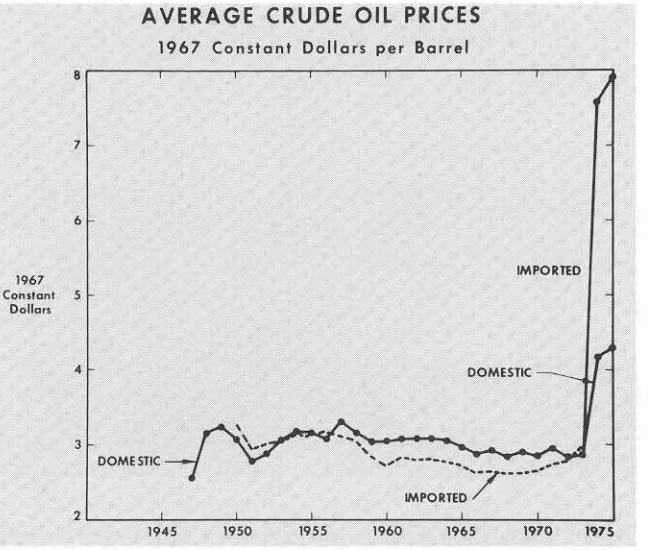
JPL, incidentally, has some work going on to understand how to extract coal more economically and perhaps how to process it more efficiently to convert it into useful products. And we have just recently started a program to try to understand some of the consequences of waste disposal from nuclear power plants.

The interesting thing about this enormous increase in the consumption of oil is that, under normal economic conditions, the price of the product would be expected to increase during the same period of time. But in 1947-48 the price of oil was actually slightly *higher* than in 1972, if compared in constant dollars. Oil actually became cheaper — until the energy crisis of 1973, when the price of imported oil quadrupled.

Obviously, the price of oil should have been rising as consumption increased. But it remained low until it finally broke loose. Had it been coming up steadily all those years, it's unlikely that we would have developed such an enormous dependence on it. So in many ways the recent jump can be regarded as necessary and long overdue.

What are the consequences of this relentless increase in oil consumption? World production has been growing in order to support that tremendous increase; U.S. production, on the other hand, peaked in 1970, and we have been pulling all the oil we possibly could out of the ground since then. Having passed the peak in domestic oil production, there is no way to reverse that process. As a consequence we have imported more and more oil. Despite the fact that prices have jumped up and the outflow of capital is enormous, this country has still not been able to come to terms with that fact.

Where does this lead us? If pessimistic estimates are right, world oil production will peak a little before the year 2000; if optimistic estimates are right, it will occur slightly after the year 2000. The difference is slight. The fact is that the whole world will have to make a

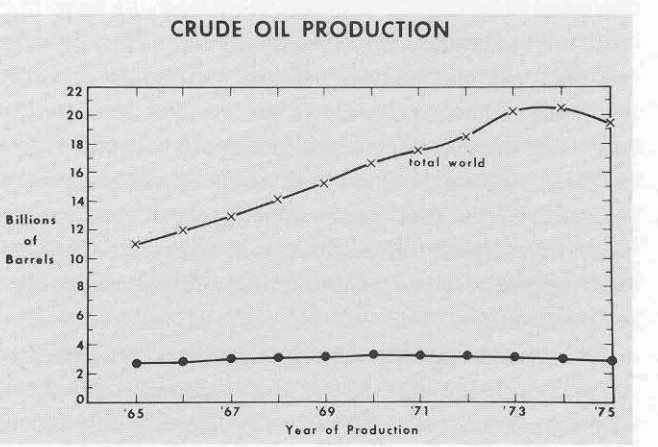


Despite the enormous increase in the consumption of oil and energy, the price of oil actually became cheaper, in constant dollars, until the energy crisis of 1973.

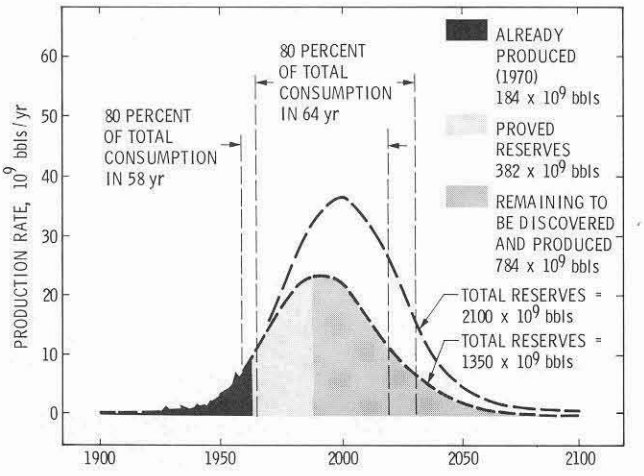
fundamental transition in about 25 years — at the time when babies now being born are becoming parents. Then the world's oil production will start declining. But it will become much more costly long before then; yet even so, we are still increasing our consumption of oil. This is a reckless course that can't lead anywhere but to a crisis of proportions difficult to exaggerate.

Regardless of whether alternative sources of energy are developed, we are going to run out of oil, and that will cause the economy and our way of doing business to change. Most importantly, the way we transport people and things will change, because that process really depends on oil.

JPL is trying to develop a good program in electric vehicles for this reason. There is no well-established



U.S. oil production has passed its peak (1970), and there is no way to reverse this trend.



We are still increasing our consumption of oil, even though world oil production will start declining around the year 2000.

industry in this area, but it seems inevitable that electric vehicles will have to provide a substantial part of our personal transport. What one does about jumbo jet liners is another matter. You can't fly those planes on batteries.

Looking back at these turbulent times, archeologists of the future may well regard us — the people who lived in the latter half of the 20th century — as "the planetary exploration culture." We were the first in the whole of human history to explore the nearby planets and the moon. But these same archeologists, when they're listing things in their equivalent of the *Encyclopedia Britannica,* will also note that our society guzzled up virtually the entire world's supply of oil in an incredibly brief period of time, without any evident concern for the consequences to ourselves, much less to our descendants. Those two things, in my mind, will stand out most sharply from this century.

I have painted a gloomy picture. Have we no choice but to give up high-unit productivity? Do we have to go to a lower standard of living to get away from it? High productivity is what has made our intellectual and artistic achievements possible (a society that has low productivity doesn't have much to leave to the future, good or bad). Are we destined to revert to an endless peasant existence? Is this confrontation between energy, economics, and the environment irreconcilable? Are we trapped between an intolerable present and an irrelevant future?

I think the way out of such pessimistic projections is to acknowledge that the present is unprecedented. We cannot circumscribe the future by limiting it in accordance with our perceptions of the past. Somehow we have to acquire fleet, faint glimpses about what can be novel and different about the future. Only in this way can we begin to discern some alternatives to what otherwise is a terrible dilemma. So I am going to try to describe some of those fleeting glimpses of the future — more as possibilities than predictions — to illustrate why I think things can be very different.

The first step is to think about the concept of regionalization — about making economic patterns work in one place without worrying about whether identical patterns will work for the whole country. A good example is geothermal energy development. This form of energy occurs in only a few places; furthermore, much of the available energy is not transportable, because it is in the form of low-grade heat. So, if its value is considered only in terms of the value of electricity that can be produced and pumped into a central grid system for wide distribution, it is not competitive with what is still relatively cheap oil. However, if the low-grade heat can be used in the same area as the geothermal deposits are found, the economics change. This has happened in Iceland and New Zealand, both pretty cold places where it is easy to find a use for the heat. If adequate energy simply isn't available, local geothermal deposits may become "economic" despite the cost comparison.

Another difficulty with geothermal energy is that in many deposits a very salty, hot brine is released, which, if spilled into the water table, can do great environmental harm. So the best thing to do, though it costs a great deal of money, is to recycle the brine back into the deposit and make it a closed system and just extract the heat and some of the pressure energy that's involved.

Why should environmental impact be given priority in new geothermal deposits when we don't seem to give it much priority in many other cases? The answer to that rhetorical question is very important. When a resource is of a regional nature and is used locally, the people who use it have to face the consequences of the environmental impact of developing it. That's not a bad way to have to frame complex decisions. Contrast this possibility with California's Proposition 15, which, in an uncharitable way, could have been phrased: "Should we have nuclear energy in California where the environmental effects, if any, will affect the people receiving the electricty, or should we instead have more coal-fired plants out in the Navajo Indian Reservations where there aren't many voters and we users will not be directly troubled by the ash and other kinds of deleterious fallout associated with large-scale coal power plants?"

There is an interesting lesson here — that regionalization tends to force a much more equitable compari-

son between environmental and economic issues. It provides a better basis for making those kinds of trade-offs.

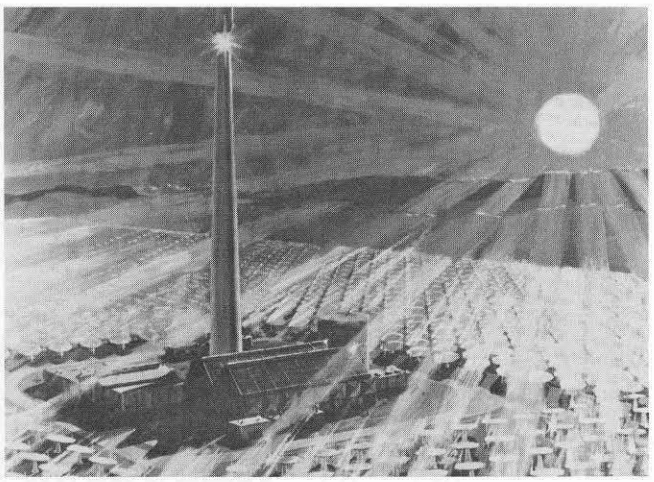
Geothermal energy is only locally available in such places as the Salton Sea, the Geysers area of northern California, and the eastern Sierra. Though it does not offer much for the country as a whole, it is still an interesting prospect for California, and JPL is trying to help in the technology and planning of that.

The real solution to energy and material needs still must involve renewable resources, which — sooner or later — the U.S. and the rest of the world must come to depend upon. A society that recycles its sources of energy and raw materials must develop. The problem is that such resources are intrinsically dispersed. Oil, coal, and uranium, for example, are highly concentrated in their natural states. One can build a power plant to extract the energy in one place and transport it widely as electricity. But solar energy, in contrast, is dispersed all over the globe. It's very difficult to concentrate it appreciably.

Sewage waste, which ultimately must become a source of basic chemicals, is as dispersed as the population. One can hardly imagine taking all the sewage, putting it in tank cars, and carrying it to the Four Corners, where huge treatment plants would extract all its goodies. If it is ever going to be useful, waste recycling will have to be done in a distributed way, in tens of thousands of municipalities throughout the country.

When we consider how technology can help us utilize our renewable resources, we must first realize that how we choose to use technology is to a large degree both a political and societal choice. One of the big jobs I see for us as a nation — and in that sense leading the world — is to try consciously to make a choice about where we're going in technology and therefore in economics.

As I said, solar energy is a dispersed resource. One would think that the right way to deal with it is to figure out how to use it regionally. But at the present time much of the major national effort is not in that direction; rather it is intended to collect sunlight in hundreds of dishes and focus the energy to a single point at the top of what's called a power tower. The collected heat will then drive a steam turbine to produce electricity. So it seems to be our national policy to treat new kinds of renewable resources in the same manner as we treat highly concentrated fossil energy deposits. I think we should indeed do this sort of thing, but we should direct a comparable effort at learning how to use solar energy and other resources in a distributed way.

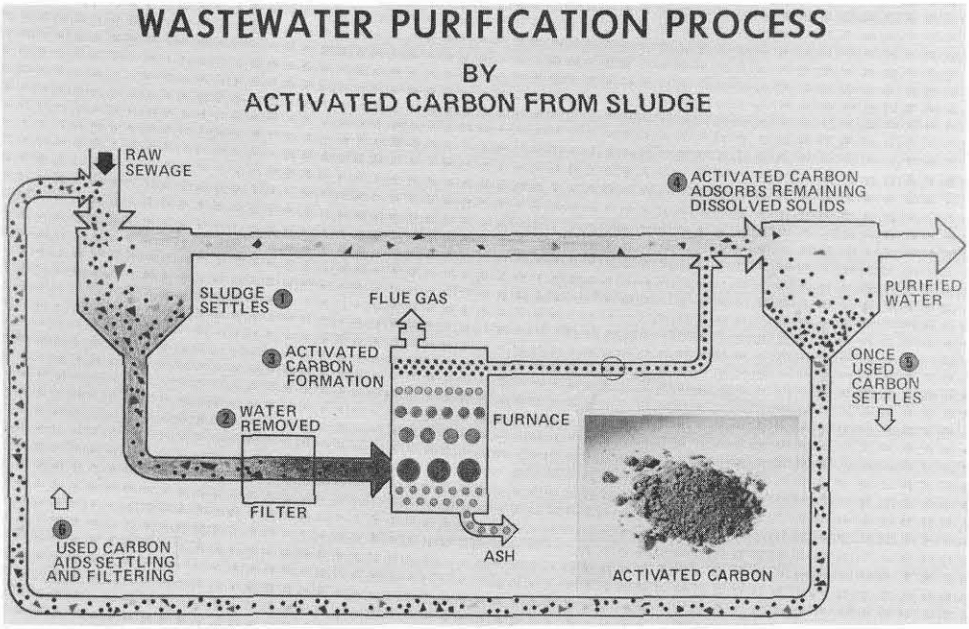


In solar energy, our major national effort is to collect this energy in hundreds of dishes and focus it to a single point at the top of a power tower.

There is another way in which solar energy impacts our society. Natural gas, one of the endangered species of energy, is used in agriculture to dry food products. A substantial amount of energy is consumed in this way. But it is possible to use a solar collector to heat water to a high enough temperature to accomplish the drying, or at least supplement the use of gas for the purpose. This is again a decentralized effort; the energy would be gathered and used in the same locality.

Another idea that's been suggested at JPL has to do with the production of ammonia fertilizer. One of the big problems to be created by the disappearance of oil is that ammonia fertilizer, which is basic to modern agriculture, is made from petroleum. As oil gets more dear, fertilizer gets more dear, and the cost of agriculture shoots up over the whole world. The green revolution is based on an energy *deficit*. It takes more energy to grow food in the green revolution than actually is extracted by eating it. This is another consequence of our binge of guzzling hydrocarbons. A novel approach would be to make ammonia in situ, perhaps in a small farming community, by using a solar energy collector to make electricity, which would be used at the same site to dissociate water into hydrogen and oxygen. The hydrogen then would be reacted with nitrogen in the air to make ammonia. All the constituents of ammonia are contained in air and water, but it takes energy to recombine the molecules. This kind of process could work all year long, though the ammonia normally is used for only perhaps four to six weeks in the planting season, when the fertilizer is put down.

Accumulating the energy chemically throughout the year, and using it only once is a clever idea that would have additional savings, because at present a significant



Orange County has just finished building a million-gallon-a-day plant using this method of processing waste.

limitation to using ammonia fertilizer is the rail transportation system. Since the ammonia is used over large areas at the same time, it is very difficult to supply it properly. If it could be produced where it is to be used, an enormous revolution could take place, perhaps as important in some ways as the green revolution. Obviously this kind of technology, if developed for the U.S., in time would be available for other places in the world.

Another way that modern technology can make an unexpected breakthrough in using renewable resources is in the area of processing waste. JPL has many people who know a lot about burning things, because they grew up in a rocket laboratory. Some years ago these people became interested in a process of sewage treatment that involved taking the sludge, heating it up, and making carbon out of it, then using the activated carbon to filter the water, resulting in a closed-cycle system. Orange County has just finished building a million-gallon-a-day plant using this process.

I've been talking about fairly mundane applications of technology, things that we can see how to do right now without having to solve any mysterious problems in physics or biology. On the other hand, there are great possibilities in what we can dimly see, or, of course, can't even envision. For example, in the case of fertilizer, if mutant strains of bacteria could be developed that were especially successful in fixing nitrogen, then the enormous global demand for synthetic ammonia fertilizer could be reduced. The same thing is true in waste processing. The ideal waste-processing system would involve a bug that loves to eat sewage and produce from it the feedstocks for petrochemicals, and thereby provide an alternate source to oil. It is not an impossibly large further step to consider.

Suppose that the coming oil crisis, and the rejection by society of large centralized economic systems, combine to produce a more dispersed and fragmented country. Does that mean that society will break apart into isolated independent groups? Is this really a pathway back to the Middle Ages — or the Balkanization of the U.S.? And does this mean the end of the tremendous global unity that has been developing in the 20th century? I think the answer is no, because another kind of technology is on the ascendancy — communications and transfer of information.

Communication will grow simply because we have the technology to do it so easily. One example I had personal experience with began in 1965 when Mariner 4, the first probe to get to Mars, flew by and returned data to Earth at 8 bits (or dashes) per second. When Mariner 10 went by Mercury in 1974, not even a decade later, the data came back 10,000 times faster!

Another enormously impressive development to me is the minicomputer, based on a microprocessor in which the guts of a computer are put almost literally on the head of a pin. What this means, for those of you who work in science and technology, is the end of the tyranny of the central computing system. We don't have to work together any more; we can each do it our own way. This result has come about through serendipity, not from any conscious planning by the government. But what it means, even more importantly, is the beginning of an individualized computer tool system.

Almost every sales person in a modern store now is beginning to operate a cash register that is not a cash register but a computer terminal. It not only takes care of financial charges; it also makes an inventory and does other things. The sales person is now a computer operator.

What I see coming is a communicating society in which information is going to be transferred rather than people or materials. A good example is the postal system, a structure that is clearly obsolete. We are not far now from the point where we will no longer physically write on a piece of paper, have it hand-manipulated by different people, have it transferred physically 3,000 miles, then hand-manipulated by people again, and finally read. For people who have a special nostalgia for this process, the old system will be available, but at its true cost, which is substantial. Instead, facsimiles of whatever it is you want to send will be transmitted electronically anywhere in the world. And someday people will look back upon the post office as something left over from the Middle Ages — and certainly from a labor-intensive society.

There is research right now at USC on a concept called telecommuting, the idea of decentralizing employees from their work by having a video link between different employee functions. This is a slow process because it is difficult to learn how to integrate the people and machines really effectively. But eventually it will be done — especially when we run out of oil. It will be a lot easier to transmit pictures of faces speaking than it will be to take the face physically and move it 20 miles, or 100 miles, or 1,000 miles.

So I see us moving into an intrinsically new kind of society, one that is not closely related to past experience. It is not easy to forecast what that will be like. I can imagine that good ideas will spread very rapidly, but the application of the ideas will be local — depending on local conditions, traditions, and attitudes. In my view, in that kind of world a great diversity could be developed and maintained, and the current global pressure toward homogenization might be reversed.

Another conclusion from this is that understanding of science and technology must be dispersed through the whole of society and become part of most individuals' consciousness. The idea of "priests" with special knowledge — like today's doctors and scientists — simply isn't going to stand up. That is a product of an overcentralized system. The whole ethic of a scientist being something special and different is hardly a hundred years old, yet sometimes scientists and laymen both act as though it was given by Moses. It will probably not last another hundred years. The knowledge that scientists have, and the handling of quantitative information, I see becoming very generally applied, and becoming part of the substrata of individuals or small groups.

In this sense I differ very much from Schumacher and Illich, who seem to look at decentralization as going back to simpler things. I see it as going on to more sophisticated technology — more advanced technology leading to a kind of life we don't yet know.

So where will all these technological changes lead? Society must change and evolve. My expectation is that on some time scale the coming communicative society will lead to communication with intelligent societies elsewhere in the galaxy among the billions of stars that are there — if we are not alone. Of course we don't know. But if there are others — if the growth of life and intelligence is a fairly common process in the universe, ultimately we will communicate with them.

What then will be the nature of this world that must emerge from this incredible and unprecedented century in which we are immersed? I see us in a distorted and overstimulated collision between the past and the future. I see us carrying out an epic struggle to rule rather than be ruled by our tools — our technology.

Dimly what I see coming — perhaps colored by optimism — is a world in which quality will grow over quantity, because the limits to growth will be reached. These will be real physical limits, not simply those of inherited ignorance or superstition. But as such limits are reached, the idea of materialism will become less significant; the idea of quality will be restored in a medieval sense to the center of man's vision. The ethics of those living then will be much more frugal and restrained, I think, than ours. As part of that indifference to materialism, I see science and technology becoming internalized by society and by individuals, not institutionalized. I think the present institutions will be looked upon in both bewilderment and amusement by our descendants. And I see a growing trend toward small-scale operations — decentralized, but using technological innovations to achieve them. Certainly if that happens it will accompany a profound change in our traditional economic structure and systems. It is my hope, and my expectation, that machines will extend human capabilities, but not eliminate human functions.

A communicative society will arise that will be characterized by local diversity and innovation but also by intercommunicating global intelligence, and eventually by communication with cosmic intelligence, if there is such. There, in my view, lies our destiny, our direction, our destination — the end of the process of which we are but a part. □