



The computer and our changing society

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Those responsible for this convention are to be congratulated for including a whole day's session on the impact of computers on society. Usually when engineers and scientists meet the subject matter is almost wholly technical. In a way this is strange because the common, quick definition of engineering is "the application of science to society's needs." If this definition were really to be taken seriously, it would mean that those who practice engineering would seek to be equally expert in science and in society, since one can hardly be professional about applying science to something he does not understand.

Engineers are only occasionally expert in the problems, needs, and organization of society. Conversely, knowing very little about science does not automatically make someone outside the engineering profession any more competent in social problems than the engineer. This is a great shortcoming of our world as we head for a much more technological civilization. There is, as a matter of fact, a missing profession—the "socio-technologist."

All in all, we may not be as prepared as we would like, but it is particularly urgent at this time to discuss the impact of the computer on our lives. More broadly, we should consider the impact of the new technology which involves all aspects of the handling of intellectual and informational tasks by electronics, and for which we will often use the word "computer" as a short, though inadequate, title. It is especially timely and important to take up the computer's relationship to society, because the computer is rapidly replacing nu-

clear energy and space as the leading technological item of confusion and fear in the public mind. We cannot today picture with completeness and precision the entire future effect of computers on our civilization. However, we can endeavor to eliminate some common misconceptions which are on their way to becoming well-established, harmful myths.

WILL THE COMPUTER REPLACE MAN?

This may be the greatest fear. It is apparent from the frequent appearance in the public press of statements such as "A computer can't think" or "A computer isn't creative—it can only do what man directs—it has no mind of its own!" These are defensive words arising from the myth that the computer is a competitor to man. It is apparently important to keep reassuring ourselves that we are intellectually superior. Thus, we rejoice when we hear that an automatic device somewhere has failed. When the electric power blackout took place in the Northeastern United States recently, many hoped to hear, and were anxious to spread the word, that a computer, to which we presumably entrusted too much responsibility, had goofed. "Please, God, don't let it turn out to be the result of a human error," was the prayer many intoned.

But that man and the computer are competitors is a misconception. Electronic information handling technology is presenting new ways to us to acquire, store, process, disseminate, and utilize the information that makes the world go round. It is making possible improved systems of production, banking, transportation, and education. The true concept is change—

change simultaneously offering two things: potential benefits and potential dislocations. A mature society will work at minimizing the negative reaction so as to emphasize the benefits. Properly handled, the computer in replacing man represents a small effect, and the potential benefits, a large effect. At any rate, fear and misconception will certainly work against realizing the benefits.

What the computer makes possible is not primarily a replacement of man or competition with man, but a new man-machine partnership. It enables an extension of man's intellectual and information handling capabilities and hence enhances man. The combination, exceeding the capabilities of unaided man, can better meet society's needs and can attain higher achievements. As to man's specific occupations that might be affected by his partnership, the result will be a new and broader spectrum of jobs, new professions, and greater satisfactions.

The X-ray machine did not compete with or replace the physician. It broadened the practice of medicine. It made it a better profession, a more intellectual one, a more useful one to society. It brought a requirement for technicians and apparatus and facilities not previously existing, all economically justified by the new technology.

The book is a machine having to do with extending man's intellect. When the concepts of printing and books were born perhaps some considered books as competitors to teachers. In a sense, they did replace something that the human educator previously had to accomplish alone, without books. But they succeeded in broadening the dissemination of knowledge, increasing communications of thoughts between people, leading to a much broader and larger educational system. Books made possible the employment of even more teachers, who brought more benefits to society than were economically achievable without the machine—in this instance, the book.

ARE EDUCATIONAL REQUIREMENTS FOR THE NEW TECHNOLOGICAL SOCIETY UNATTAINABLE?

There is a growing alarm that the educational requirements for the decades ahead simply cannot be met. The technological life toward which we are headed requires increasingly broader education of every young person to prepare him to make a living and to be a good citizen. A larger fraction of adults must now continue education to keep up with the rapidly expanding order of change and remain productive. Meanwhile it is seemingly becoming more difficult to provide

this education. The cost of facilities and the demands for educators are escalating, and shortages seem certain to grow. This educational crisis is often blamed on technological advance. The technological society generates, it is claimed, impossible demands for education and hence guarantees its own failure and collapse.

A breakthrough in educational concepts is clearly needed—something comparable with printing and the book. Advanced electronic technology offers precisely the kind of new concepts needed to revolutionize the educational process. Human educators can be assisted by networks of electronic facilities that are backed by an educational industry that does not even exist today. Educational experts will be able to plan present, test, and analyze with great enhancement of their informational and intellectual powers, rising to a new plateau of accomplishment. Here the man-machine partnership can provide a match between society's needs for all kinds of education, and society's ability to supply that need.

Embryo teaching machines of today are as far away from the full use of technology in education as the first stone tablets are from today's television network. Matured computer and electronic networks, applied under the skillful direction of educators and engineers working together, can provide new forms of education in the home, in schools and in industry. Educational communication satellite systems can provide to a special network in the homes of the nation a choice of hundreds of different courses of study chosen simply by pushing the right buttons on the home educational TV set. Carefully presented programs available when called for can involve student identification and participation, the answering of questions by pushbutton, the monitoring of answers by "live" experts, and a record of results.

In schools, material can be presented not only by the human educator in person, but through audio-visual devices which can automatically speed up, slow down, or switch to a completely different presentation, all in automatic response to the student's apparent ability to follow the material. That is, the presentation can periodically include questions to the student, the answers to which can influence further presentations to suit the student's pace. Computer systems can keep track of the progress of millions of students. These systems can compare progress against estimates and can make possible statistical analyses and a type of creative planning not now remotely practical. At the same time, an individual student can have synthesized for him presentations or tests completely unique to his particular requirement. These can be determined by the virtually instantaneous availability of a full record of

progress and a comparison of that record against alternate courses for him to take in the future.

Electronics does not separate the student from the human teacher any more than the electrocardiograph keeps the physician from having direct contact with and interest in his patient. On the contrary it enables him to "listen" to his patient's heart with greater skill. Comparably, the human educator will be able to consider an enormously larger number of facts about both student and course with greater accuracy and confidence. He will be able to make available to the student more material with greater efficiency and with a much broader selection. He will be able to reach the eyes, the ears, and the minds of students, children and adults alike, everywhere. He will be able to propose new concepts in education and to check his plan to discover how it worked, and then alter and improve it.

In the coming technological society, education can become the greatest occupation of man and his greatest preoccupation as is required to meet the challenges of the age. The educational profession will expand into a larger number of specialties, and it will be equipped to do more research to achieve important generalizations to guide its members in that educational acceleration. Educators will have the support of a huge industry that provides systems engineering, communication networks, information dissemination, storage and retrieval, and analysis techniques capable of supporting the higher educational plateau.

It is a myth to think that rapidly advancing technology is creating an impossible dilemma in education. It is rather that the crises that have been developing for years in education may at last be attacked with a scope equal to the task by the utilization of advanced technology.

WILL THERE BE NO NEED FOR UNSKILLED LABOR?

The leading "dark horse" candidate for the myth of the century may be this: modern technological society eliminates the need for unskilled labor. Since, no matter how technology is used for the good of society, not everyone will be well educated and competent to work at highly intellectual pursuits, this myth suggests we will permanently have a growing number of unskilled and unemployed citizens. I venture to predict that after some initial dislocations, and within the period of a decade, we shall commence to realize that, far from there being a shortage of jobs for unskilled labor, there may well be a shortage of unskilled labor to fill jobs.

To see why this is so let us move ahead to the year

2000. Let us also assume, in complete consistency with the premise of the myth, that unskilled labor will no longer be needed because we will have reached an essentially fully automated society. The factories will turn out all of our material needs through nearly automatic operation with little intervention by man. There will be moving sidewalks and automatic rapid transit cars in the cities which, like today's automatic elevators, will perform without human operators. None of us will use coins or currency anymore. We will instead assume that when we buy a necktie or a piece of land we simply hold our finger against a little window so our fingerprint can be scanned electronically, then in the record-keeping facilities thousands of miles away something will be taken off our account and put on someone else's account. Let us assume that automobiles, missiles, and houses are designed by automatic computer programs. The tests taken of each of us in the hospitals will be automatically recorded and analyzed, and a treatment prescribed with little intervention by human operators or analysts.

This is an exaggeration, an extreme description of a fully automated age. However, this route enables us quickly to arrive at a series of important points. The world fitting our description is reachable only by a complete redoing, updating if you will, of our entire national physical resources to take advantage of technology to reach the fullest automaticity conceivable. To achieve such a system, even if it were possible or desirable, would require an expenditure per year far exceeding our gross national product. It would mean virtually creating a whole new nation full of new expensive facilities and resources and a newly developed and implemented way of operating them. Our cities, factories, hospitals, schools, and transportation systems would all have to be rebuilt. We do not have the total resources in manpower, skilled and unskilled, to accomplish this transition by the year 2000. Even if it were economically or socially sound, even if there were individual or cooperative incentives to seek to achieve it, the total cost would be too great. We simply don't have what it takes.

But this is another way of saying that, in a basic sense, a major transition of this sort is economically unsound. What really will happen will be much more sensible. To use advancing technology to improve all aspects of our society will involve the proper use of people and things, men and machines. The only practical and reliable plan is to make an optimum selection from these two categories for the tasks to be performed. Now, man can be produced with relatively cheap labor, and can be trained to do an enormous variety of tasks with his brains and senses while having physical mobili-

ty, for a rather reasonable initial and annual maintenance cost. By comparison with a certain class and variety of jobs man can do, a machine designed to do the same tasks becomes absurdly expensive. We can abbreviate this analysis by asking a substantive and symbolic question: *In the highly automated society who will change the light bulbs?* That is, associate each of us with a large number of black electronic boxes that do virtually everything automatically, eliminating the need for unskilled labor, and ask who would interchange the boxes when one of them malfunctions or wears out? Perhaps the ready answer is that this also can be done automatically. Then we must assume the design and building of still more electronic boxes to maintain the first set and these must respond to automatic diagnosis devices, calling out automatic putting in of spares and the automatic transportation of equipment from one place to another. Obviously, the extreme of trying to do away with man entirely is as silly at the level of the unskilled as it is at the skilled level. Nor does it make sense to design a way to operate our society to provide for all of our physical, intellectual, and cultural needs without intervention by man.

A city consisting entirely of trained engineers and scientists might either have to remain dirty, or depend on a means of drafting creative people for an hour or so a day to keep it clean. Or else the skilled workers might have to put their time and resources into designing a city that keeps itself automatically clean, even though this might be so expensive in the use of their time and resources as to prevent their realizing many other more important benefits.

The intelligent means of accomplishing that which man needs and wants done in society is to use an optimum partnership of man and machine at all levels of skill. This most favorable condition may be difficult to reach in the future because the percentage of unskilled workers who will be matched to the duller, mundane, less intellectual task will be fewer than the demand. As society moves forward, as we broaden the spectrum of man's activities as a result of his being able to make use of machine partners on the intellectual-informational front, and as more people become educated, we may find ourselves forced to a greater than optimum reliance upon the machine just because of a shortage of unskilled labor.

IS TOO RAPID A RATE OF CHANGE DISORGANIZING SOCIETY?

It is becoming common for all of us to complain that we can't do anything these days without a huge exercise

in frustrating arrangements. Life is becoming too complex and we associate this with its being one of rapid technological acceleration. Because earlier societies were simple and understood, they appeared well organized. The computer age seems to be headed for increasing confusion.

Fortunately, the computer is the foe of disorganization and chaos. It is the tool of all time for carving orderly patterns of control. Indeed, the computer has just arrived in time. Electronic information handling systems are being developed and installed just fast enough to prevent our being completely drowned in a sea of red tape. The problem of keeping track of everything that has to be included to keep the operation of the world running is growing, and the ability of electronic systems to help us keep our heads above water is timely and fortunate. Electronic systems are ideally suited to gathering information, assembling facts, applying logic, and controlling the flow of all needed data and directions. The constraint to smooth physical operations of our civilization today is a bottleneck of paper, of information handling. It has been bad enough in the recent past but, in the future, without modern computer networks, none of us would be able to get our pay checks, keep our insurance policies active, obtain our bank statements, deliver messages, keep track of who owns what, and maintain a semblance of order. Without electronic systems now being developed and implemented we would have, in short, a much lower standard of living and approach the very chaos we fear. The misconception here about the impact of the computer is a sort of "guilt by association." But the computer is the hero and not the culprit, the defender and the hope, not the attacker and the villain, of our fast-paced, increasingly complex society.

WILL THE FUTURE CONSTITUTE A ROBOT CIVILIZATION?

It is becoming increasingly common to believe, with resignation and chagrin, in the certainty that ours will become a robot civilization. Man is envisioned as becoming, in the future, an anonymous cog in a vast interconnection of cables, computers, signals, and moving vehicles. The world is pictured as a place where every action of society to its infinite details will be planned and controlled, with a man a mere number, an apathetic, nonparticipating disinterested bystander in decision making.

Such a structuring of society is inconceivable unless one simultaneously postulates the existence of a pervasive, automatic electronic information system that

senses all of the data needed to control our daily operations; one that is busily engaged on a mass scale in communicating information, to which machines and men all respond. Now, if such a system were to exist at some future date, it would make possible a mode of social operation which would be quite the opposite of robotism. A ubiquitous electronic information network, as effective and efficient as this, would make possible the disseminating to every citizen of all items of information worth evaluation for the selection of goals by the people. This network could gather opinions and use this polling in the making of decisions.

The technological advances that one must assume to be concerned over a future robot society would also make possible individual participation in our homes of a form of "instantaneous democracy." The same system that can tell millions of people exactly what to do can just as well ask them to choose what to do from a group of well-presented alternatives. The citizens of the future, so far as technological potentials are concerned would be able to tune in on the highest level discussion of the big issues and take part by expressing their opinions electronically from their homes in the deliberations of the Congress, state legislatures, and city councils. I am not suggesting that it would be to our advantage to have every citizen share in every decision that affects the complex operations of our nation. But the same technological system that makes possible a robot society, where everything is controlled because all the information needed for control is at the right place at the right time, also can enhance democracy. It can make possible an informed, interested public, the tapping of citizen opinion on issues, and the creating of vast loops of citizen participation in decision making.

Whether we move towards a robot society or in the direction of "on-line democracy" is not determined by technology. Science merely offers us the choice. A misunderstanding of the possibilities, a firming up and prior acceptance of the myth of robotism may keep us from having a choice.

WILL FREE ENTERPRISE BECOME EXTINCT?

The advent of the computer age appears to many to carry with it the dreaded planned economy. They forecast an automated socialism without free enterprise or private capital at risk, a detailed control of the economy, meaning "state control." Their fear is that we will lose creativity, individual initiative, the advantages of competition and incentives and, especially, give up the freedom to take individual paths to the new heights which men can attain when unhampered

and not overly controlled. Nor is it consoling that the Soviet Union's attempts to completely control her economy by planning from above is falling short of her goals in practice. The fear is that perhaps the Soviet Union tried to do it without the means; with a broadly based network of electronic information systems it might become technically practical. Then if the government and the people choose to do so, they can arrange for this kind of a controlled society in the future.

To many individuals there appears to be only two paths. One leads to planned economy, the socialistic state. The other winds back to 19th century entrepreneurship, so important in building America's economy but hardly accessible to us now. But it is submitted that there is a third, much more likely path. It leads to the creation of a free market of an unprecedented form and level.

To perceive this route we need to note first that planned economy cannot really control in detail unless the consumer is in the loop. Perhaps the Soviet Union has proven this point; although the government can plan what to produce, it cannot force the citizens' utilization of the products in accordance with the plan. As we try to do this in the technological society again we must assume the existence of an all-embracing electronic information system that can reach every man and machine. If we can communicate with everyone to ensure the working of the economy, as planned, we can also ask everyone what they want out of available product possibilities. We go on now to note, oversimplifying perhaps to make a point, that the essence of true free enterprise and our capitalistic system is the free market. So long as we have a means for people to freely choose on what they will spend their money, so long as the producer is able to offer his ideas and goods publicly for sale, then we will continue to have the advantages of free enterprise. It is only a detail how automated the flow of information is, if that information flow is used to step up the process of consumer selection, capital investment, production, and distribution.

So the basic concept is that a national electronics information system that has the technological capacity to effect a thoroughly controlled economy in principle, run from the top (the government), must also provide the necessary communications for a vast consumer free market network run from the bottom (the buying public). In fact, a nation which has a working electronic information network reaching every nook and cranny of its economy can create a free market of a form and on a level that civilization has never previously known. It could be a market in which everyone knows quickly what is available. A proposal to produce something of interest to possible purchasers could be quickly viewed

and assessed by potential buyers. Each of us in our homes could electronically respond directly to a "commercial" that describes next year's contemplated automobile models and offers a substantial discount for orders placed now. We could step to our sets and push the right buttons to confirm our purchases. This kind of direct consumer information applied to vacations, houses, soap, refrigerators, and even educational courses could be used by the automated network to schedule in detail, from the ordering of basic raw materials to the setting up and manning of plants and facilities. Planning and control is not practical if based on scheduling from the top. But it can work if based on commitments by the buying public that can be followed through, and on the basis of which plans can be made with confidence. With a potential free market which could be made to exist by the year 2000 in an automated, electronic, rapid, all-embracing on-line form, planning that includes the consumer would be possible by the entrepreneur. This is an entirely new form of free enterprise, different and quite superior to the 19th century form. Capital investment in an environment of a fast-responding customer, an "electronically" informed, interested, active market, makes possible increases in the profit-to-risk ratio. Given the opportunity to participate in an accelerating free enterprise which advanced technological systems make possible, then we might expect people to enthusiastically pursue this path. Ideas for new products quickly disseminated would beget other ideas. Efficient scheduling for production and distribution would leave more resources for risk-taking.

It is equally important to note that a strong role for the government will exist. This is to provide service and to referee, control and assure objectivity, honesty, and opportunity in this free market which depends on such a huge national electronic information service. The government will be so busy implementing this service and it will be under such pressure from the voters to further expand individual participation in the free market, both as consumer and risk-taking supplier—everyone will want expanded opportunity to participate and benefit—that we will not need to worry about the government's seeking to plan the economy from the top.

In the future, technology does make possible a kind of automated socialism, a regimented, government-controlled economy, poor as that might be. But it also makes possible a government-aided, unprecedented

level of genuine free enterprise with creativity, incentive, competition, and individual initiative carried to a new golden era of opportunity for man.

THE IMBALANCE OF TECHNOLOGICAL AND SOCIAL ADVANCE

The growing myths and misconceptions about the impact of computers and other advanced technological additions to our society have their overall foundation in the mismatch between rapidly accelerating scientific progress on one hand, and lagging social advance on the other. This imbalance is shown in our having developed an ability to release tremendous amounts of energy virtually able to destroy civilization before we have social maturity sufficient to preclude this possibility. We are on the frontier of radical advances in biology that can conquer diseases and prolong human life, while still socially unable to handle birth control, and thus we must be continually concerned with the problem of population explosion. Our large space program, justifiable as it might be for research and commerce, arose not because of an appreciation of these factors by the citizenry, but because of a prestige race with another nation. Finally, we have the possibility through automaticity of providing easily for man's material needs, but we are afraid we may not be able to handle the subsequent dislocations. It is these inconsistencies resulting from our socio-technological imbalance that are producing problems today, and not scientific progress.

The computer is not the source of imbalance, it is a tool that can accelerate civilization's progress and bring technology and society into alignment. Computers give us more brainpower. Properly used they can help us increase our natural brainpower by improved education. They can increase our utilization of man's mind. They can give us tremendously greater informational-intellectual capacities. A man-machine partnership, with the computers handling the mundane, rapid processing of data and providing instantaneous display of information where it is needed, allows man to rise to the higher intellectual pursuits. That is, the computer will make us smarter. Perhaps, we will even become smart enough to broaden our humanistic perspective. Then we can apply scientific innovation universally for the moralistic as well as economic good of our society.