CBC MASSEY LECTURES

THE REAL WORLD OF TECHNOLOGY

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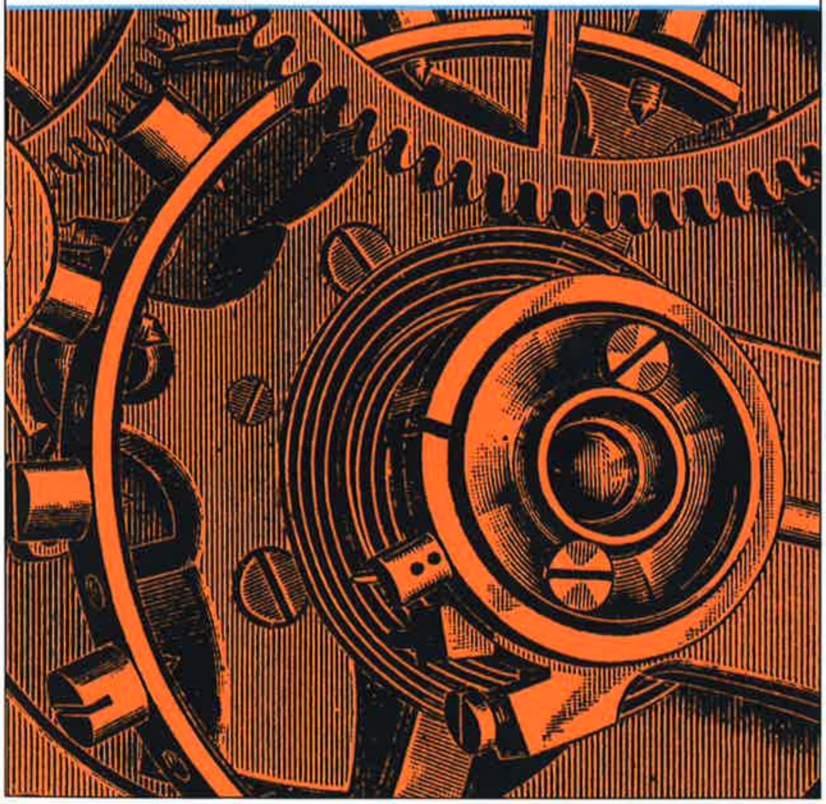

I

I start from the premise that we are living in a very difficult, very interesting time, a time in which a major historical period is coming to a convoluted end. I think we live in a time in which the social and political upheaval is as great or greater than it was at the time of the Reformation. And so I would like to do a bit of orienteering and map-making so the discourse in which we all have to engage can be conducted in a common language.

As I see it, technology has built the house in which we all live. The house is continually being extended and remodelled. More and more of human life takes place within its walls, so that today there is hardly any human activity that does not occur within this house. All are affected by the design of the house, by the division of its space, by the location of its doors and walls. Compared to people in earlier times, we rarely have a chance to live outside this house. And the house is still changing; it is still being built as well as being demolished. In these lectures, I would like to take you through the house, starting with the foundation and then examining with you the walls that have been put up or taken down, the storeys and turrets that have been added, the flow of people through the house — who can come in, who can go into particular spaces.

In the past, I have often spoken about the social impact of technology in terms of apprehension and foreboding, but this is not my purpose here. *My interest is in contributing to clarity.* I want to know as much as possible about the house that technology has built, about its secret passages and about its trapdoors. And I would also like to look at technology in the way C. B. Macpherson looked at democracy[1] — in terms of the real world. Technology, like democracy, includes ideas and practices; it includes myths and various models of reality. And like democracy, technology changes the social and individual relationships between us. It has forced us to examine and redefine our notions of power and of accountability.

In this lecture, I would like to talk about *technology as practice*, about the organization of work and of people, and I would like to look at some models that underlie our thinking and discussions about technology. Before going any further, I should like to say what, in my approach, technology is not. Technology is not the sum of the artifacts, of the wheels and gears, of the rails and electronic transmitters. Technology is a *system*. It entails far more

than its individual material components. Technology involves organization, procedures, symbols, new words, equations, and, most of all, a mindset.

In subsequent lectures, I will focus on technology as it has changed our realities of time and space. I will talk about planning and forecasting, and about the many attempts to predict the impact of technology. It will also be necessary to deal with the confusion that sometimes exists between the notion of the so-called objectivity of technology and the fact that, in a narrow sense, some of the outcomes of technological processes are predictable. It will be important to examine the human and the social impacts of technology, and we must talk about the changing nature of experience, as well as about the fragmentation of knowledge and work. We need to examine the new social class of experts, as well as the changing nature of community and constituency that has been brought about by technological systems. Technology also needs to be examined as an agent of power and control, and I will try to show how much modern technology drew from the prepared soil of the structures of traditional institutions, such as the church and the military. I will also talk about scale and complexity and about the modem technologies of management and government. I would also like to talk about some of the technologies that are of particular interest to me, such as communications technologies and computers. I will trace in one of the lectures the life-cycle and pattern of development of specific technologies from innovation and incipient development, through to the point when the technologies become entrenched in the social landscape. And I would like to touch on the place of the natural environment when examining technologies as agents of change. I will trace back some of the themes, so that we might see what developments and social transformations will be needed for the real world of technology to become a healthy and sane habitat for human beings.

There exists a vast literature on all aspects of technology.[2] Recently, people have become particularly interested in technology's social impact. I myself am overawed by the way in which technology has acted to reorder and restructure social relations, not only affecting the relations between social groups, but also the relations between nations and individuals, and between all of us and our environment. To a new generation, many of these changed relationships appear so normal, so inevitable, that they are taken as given and are not questioned. Yet one can establish clear historical trends. In order to understand the real world of technology and cope with it, we need to have some knowledge of the past, as well as to give some thought to the future.

Altogether there seems to be a very drastic change in what it means today to be human — what it means to be a woman, a child, a man; to be rich or poor; to be an insider or an outsider — compared with what all this meant in the past. My father was born just before the turn of the century, and many of his approaches to life could be understood from knowing that he was a German intellectual, a member of an old family of a particular social class, coming from a particular region of the country. On

the other hand, you would know very little about my son's approach to life and his values and attitudes by knowing that he is a photographer, born in the late 1950s in Toronto. Technology has muddled or even destroyed the traditional social compass.

It is my conviction that nothing short of a global reformation of major social forces and of the social contract can end this historical period of profound and violent transformations, and give a manner of security to the world and to its citizens. Such a development will require the redefinition of rights and responsibilities, and the setting of limits to power and control. There have to be completely different criteria for what is permissible and what is not. Central to any new order that can shape and direct technology and human destiny will be a renewed emphasis on the concept of justice. The viability of technology, like democracy, depends in the end on the practice of justice and on the enforcement of limits to power.

Let me begin now, like any good academic, with definitions. To define technology in a global sense is really quite fraught with difficulties; the best minds among philosophers, historians, social scientists, and engineers have attempted to do it.[3] I will not compete with them. Rather, I would like to define, as we work through this, technology in its various aspects within the context in which they occur and within the context in which I discuss them. Like democracy, technology is a multifaceted entity. It includes activities as well as a body of knowledge, structures as well as the act of structuring. Our language itself is poorly suited to describe the complexity of technological interactions. The interconnectedness of many of those processes, the fact that they are so complexly interrelated, defies our normal push-me-pull-you, cause-and-consequence metaphors. How does one speak about something that is both fish and water, means as well as end? That's why I think it is better to examine limited settings where one puts technology in context, because context is what matters most.

As a beginning let's look at technology as practice. Kenneth Boulding, the author of *The Image* and many other influential books in the social sciences,[4] suggested that one might think of technology as *ways of doing something*. He pointed out that there is a technology of prayer as well as of ploughing; there are technologies to control fear as well as to control flood.

Looking at technology as practice, indeed as formalized practice, has some quite interesting consequences. One is that it links technology directly to culture, because culture, after all, is a set of socially accepted practices and values. Well laid down and agreed upon practices also define the practitioners as a group of people who have something in common because of the way they are doing things. Out of this notion of unifying practice springs the historical definition of "us" and "them." I think it is important to realize that the experience of common practice is one of the ways in which people define themselves as groups and set themselves apart from others. "Around here, that's how we do things," a group will say, and this is their way of self-identification, because "others" may do the same thing differently. A different way of doing something, a different tool for the same task, separates the outsider from the insider.

I once was invited to examine Chinese bronzes at the Freer Gallery of Art. The purpose of the gathering was to develop suggestions for research into the technology of Chinese bronze casting, to share knowledge and to avoid duplication. We were about six or eight, and I will never forget the scene. Most participants were art historians or museum people; I was the only researcher coming out of engineering. We were all looking at bronze fragments and we all had magnifying glasses, but my magnifying glass was different from the magnifying glasses that everyone else had. "They" had magnifying glasses that they put to their eyes and then lifted the object into proper viewing distance. I had a magnifying glass that I put on the object, and I manoeuvred my head into a good viewing position. They took one look at my magnifying glass and I was out. I was classified as an outsider. I was treated politely. A lot of good relationships came out of that meeting. Still, I can recall to this day that feeling of distance, the surprised looks. I knew I was respected, but I just wasn't one of them.

On another occasion I sat in the back of a large meeting room, listening to a long and boring discussion. I began to knit. A young woman came over, sat down next to me, and whispered, "I'd like to talk to you. You knit just like my mother." Of course, her mother was also German, and there is a German way of knitting.

The historical process of defining a group by their agreed practice and by their tools is a powerful one. It not only reinforces geographic or ethnic distributions, it also affects the gendering of work. When certain technologies and tools are predominantly used by men, then maleness becomes part of the definition of those technologies. It is for these deep-rooted reasons that it is so very difficult for women to enter what are now called "non-traditional" jobs. If engineers are male and maleness is part of engineering, then it's tough for men to accept women into the profession. The apparent ease with which women acquire the knowledge necessary to practise only seems to increase the perceived threat to the male practitioners. And so year after year, engineering faculties go through initiation procedures that are crude, sexist, and obscene in order to establish that the profession is male, even if some of the practitioners are not.

The common practice that a particular technology represents, in addition to leading to an identification with culture and gender, can also lead to the "right" of the practitioners to an exclusive practice of the technology. This is how the professions were born; clergy, doctors, lawyers, engineers, and social workers all claimed the exclusive right to certain tools and to certain technologies.

Another facet of the concept of technology as practice is the fact that the practice can define the content. I spoke earlier of Kenneth Boulding's remark that there is a technology of prayer as well as a technology of ploughing. The sacred books of most religions lay out the practices of prayer quite precisely, and that laying down of the practice means that other forms of worshipful activities, however deeply they may be felt, cannot be considered legitimate

prayer. For instance, the playing of or listening to a particular piece of music may very well be felt as a deep plea for deliverance, but it isn't prayer. One has to keep in mind how much the technology of doing something defines the activity itself, and, by doing so, precludes the emergence of other ways of doing "it," whatever "it" might be. This has been so historically but it is even more so today, because so many activities are technologically structured.

It becomes so easy and seemingly objective to define the content by the way something is being done or prescribed to be done. Teaching, for instance, is now a clearly circumscribed activity that takes place in a particular location and is conducted by particularly trained or ordained practitioners, and whatever somebody may teach you in working together with you, it isn't the kind of learning for which you ever get a credit. I think it's important to realize that technology defined as *practice* shows us the deep cultural link of technology, and it saves us from thinking that technology is the icing on the cake. Technology is part of the cake itself.

Let's distinguish the two ways in which technology has developed. In the first place there are work-related technologies. Work-related technologies make the actual practice easier. Take, for instance, the substitution of electric typewriters for mechanical ones; this is indeed a work-related technological improvement. Secondly, there are control-related technologies, those developments that do not primarily address the process of work with the aim of making it easier, but try to increase control over the operation. Think of a word processor. A freestanding word processor is indeed work-related technology. But link those word processors into a work station — that is, into a system — and the technology becomes control-related. Now workers can be timed, assignments can be broken up, and the interaction between the operators can be monitored. Most modern technological changes involve control and thus new control-related applications have increased much faster than work-related ones.[5]

It is not difficult to understand the difference between control- and work-related technologies, but I would now like to introduce a concept that may be somewhat more difficult to grasp. I want to distinguish between two very different forms of technological development. The distinction we need to make is between *holistic technologies* and *prescriptive technologies*.[6] Again, we are considering technology as practice, but now we are looking at what is actually happening on the level of work. The categories of holistic and prescriptive technologies involve distinctly different specializations and divisions of labour, and consequently they have very different social and political implications. Let me emphasize that we are not asking *what* is being done, but *how* it is being done.

Holistic technologies are normally associated with the notion of craft. Artisans, be they potters, weavers, metal-smiths, or cooks, control the process of their own work from beginning to finish. Their hands and minds make situational decisions as the work proceeds, be it on the thickness of the pot, or the shape of the knife edge, or the doneness of the roast. These are decisions that only

they can make while they are working. And they draw on their own experience, each time applying it to a unique situation. The products of their work are one of a kind. However similar pots may look to the casual observer, each piece is made as if it were unique. Here are a few lines from the poem "The Land" by Vita Sackville-West, which convey the meaning of holistic technologies: "All craftsmen share a knowledge. They have held reality down, flattened to a bench; cut wood to their own purpose, compelled the growth of pattern with the patient shuttle. Control is theirs."[7] Using holistic technologies does not mean that people do not work together, but the way in which they work together leaves the individual worker in control of a particular process of creating or doing something.

A quote from Melville Herskovits, taken from his *Economic Anthropology*,[8] is also helpful. He points to the often very sophisticated specialization one finds historically in various societies, and he writes ". . . certain men and woman [*sic*] specialize, not only in one technique, but in a certain type of product, as, for instance, where one woman will devote her time to the production of pots for everyday use and another will make pottery exclusively for religious rites. It must again be stressed that, except under most unusual circumstances, we do not find the kind of organization where one woman characteristically specializes in gathering the clay, another in fashioning it, and a third in firing the pots; or, where one man devotes himself to getting wood, a second to roughly blocking out the proportions of a stool or figure, and a third to finishing it."

It is the first kind of specialization, by product, that I call holistic technology, and it is important because it leaves the doer in total control of the process. The opposite is specialization by process; this I call prescriptive technology. It is based on a quite different division of labour. Here, the making or doing of something is broken down into clearly identifiable steps. Each step is carried out by a separate worker, or group of workers, who need to be familiar only with the skills of performing that one step. This is what is normally meant by "division of labour."

This type of division of labour is most familiar to us as it arose in the Industrial Revolution in Britain. The factory system of the time resulted from large-scale applications of such divisions of labour.[9] However, this kind of division of labour is actually much older. We find it among the late Romans, whose Terra Sigillata pottery or Samian ware was produced by a prescriptively controlled technology. Items were essentially mass-produced to very close tolerances, and we have good written descriptions of the labour organization and of the technology, as well as examples of the artifacts themselves.[10] But even a thousand years earlier there was the production of Chinese bronze vessels, organized as a prescriptive technology *par excellence*, with clearly defined process-determined divisions of labour.[11]

The Chinese way of casting bronze — and it began well before 1200 BC — is indeed a *production* method. It is also unique to China, where later the same division of labour and the same method of production was used for the casting of iron. This resulted in the appearance of cast iron in China more than a thousand years before cast iron was

produced in the West. Before that time, iron was mainly fashioned as wrought iron by a technology that is much more holistic. In fact, the making of wrought iron is almost the prototype of a holistic technology.

I'd like to take a moment to describe Chinese bronze-casting techniques, not only because I love Chinese bronzes and I have spent a lot of my professional life studying them, but also because Chinese bronze casting is such a magnificent example of prescriptive technologies and their social impact. Please don't think that considering the details of Chinese bronze casting has nothing to do with the topic at hand. Understanding the social and political impact of prescriptive technologies is, in my opinion, the key to understanding our own real world of technology.

Imagine, then, it is 1200 BC, the height of the Shang Dynasty. A large ritual vessel has to be cast — let's say a cauldron, a three-legged Ding, examples of which can be seen in the Royal Ontario Museum. First a full-size model of the Ding is made. It is usually made in clay, although it could be wood. Archaeologists have discovered lots of these models; such a model is a complete likeness of the vessel and all its decorations. From this model a mold is made. This is done by putting layers of clay — first very fine clay, then coarser material — onto the model and letting this coating dry. The mold is then carefully cut into segments and taken off the model in the way we take the peel off an orange. Because the mold is taken off in pieces one speaks about a "piece mold" process. The mold segments are then fired so they keep their shape and their decorations. They must be fired at temperatures that are higher than the temperature of molten copper or bronze, which the mold later contains. Consequently this casting technology became possible only in a civilization that had developed the techniques for producing high-fired ceramics.

Once the piece molds are fired, they are reassembled around a core, leaving a gap between the core and the mold large enough to receive the molten metal. The mold assembly has, of course, to include a means of pouring the liquid metal into that gap between core and mold as well as ways for the air that the liquid metal displaces to escape completely so that the casting is of good quality. Once the mold assembly is finished and properly positioned in a casting pit, the liquid bronze can be poured.

Up to this point in the process, essentially two main steps have been executed. The designer and model builder have constructed the model in a manner that allows the formation and the cutting away of the mold. This involves design expertise as well as a full knowledge of all subsequent steps in the process, because they all depend on the proper design of the model.

The next steps of building up the mold, of cutting it away, firing it, and reassembling it around the core in order to make it ready for casting, constitute a series of operations where the expertise is essentially that of pottery work.

The casting steps that follow the assembly of the mold require different expertise. Here the metal has to be prepared; the alloy has to be mixed in proper proportions and fused to a temperature high enough to allow a

successful casting. Most, if not all, Chinese bronzes contain, in addition to tin, enough lead to make possible the casting of objects with very finely and elaborately designed surfaces. We are here talking about large castings. It is astonishing that towards the end of the Shang Dynasty, the Chinese cast cauldrons that weighed eight hundred kilograms or more. From technical studies, such as X-rays of the vessels, we know that they were essentially cast in one pour. This means that groups of metal workers were handling about a thousand kilograms of liquid bronze to cast a large vessel. These alloys melt above 1000°C. They were poured from crucibles; a large number of them had to be ready for pouring at approximately the same time.

Just imagine yourself in charge of such a labour force. And remember, these castings were not extraordinary events. The archaeological record shows that such castings were done routinely. The amount of material found, and the knowledge that this constitutes only a small fraction of what was produced, assures us of the presence of a large, coordinated production enterprise.

It was only when I considered in detail — as a metallurgist — what such a production enterprise would entail, that the extraordinary social meaning of prescriptive technologies dawned on me. I began to understand what they meant, not just in terms of casting bronze but in terms of discipline and planning, of organization and command.

Let's focus, for instance, on the need for precision, prescription, and control that such a production process develops. In contrast to what happens in holistic technologies, the potter who made molds in a Chinese bronze foundry had little latitude for judgement. He had to perform to narrow prescriptions. The work had to be right — or else. And what is right is laid down beforehand, by others.

When work is organized as a sequence of separately executable steps, the control over the work moves to the organizer, the boss or manager. The process itself has to be prescribed with sufficient precision to make each step fit into the preceding and the following steps. Only in that manner can the final product be satisfactory. The work is orchestrated like a piece of music — it needs the competence of the instrumentalists, but it also needs strict adherence to the score in order to let the final piece sound like music. Prescriptive technologies constitute a major social invention. In political terms, prescriptive technologies are *designs for compliance*.

When working within such designs, a workforce becomes acculturated into a milieu in which external control and internal compliance are seen as normal and necessary. Eventually there is only one way of doing something. The Chinese could probably not have imagined making bronze in any other manner, just as we can't imagine cars being manufactured in any other way than the way it's done today around the globe.

Bronze-making was not the only prescriptive technology in ancient China. Similar approaches are found in the making of warp-determined textiles and certain pottery productions. I've argued that the historically very early acculturation of Chinese people into prescriptive work

processes must be regarded as a formative factor in the emergence of Chinese social and political thought and behaviour.[12] This includes the early emergence of a Chinese bureaucracy in its all-encompassing forms, the Imperial examinations, and the stress on *li* — the right way of doing something.

Today's real world of technology is characterized by the dominance of prescriptive technologies. Prescriptive technologies are not restricted to materials production. They are used in administrative and economic activities and in many aspects of governance, and on them rests the real world of technology in which we live. While we should not forget that these prescriptive technologies are often exceedingly effective and efficient, they come with an enormous social mortgage. The mortgage means that we live in a culture of compliance, that we are ever more conditioned to accept orthodoxy as normal, and to accept that there is only one way of doing "it."

As time went on more and more holistic technologies were supplanted by prescriptive technologies. After the Industrial Revolution, when machines began to be added to the workforce, prescriptive technologies spread like an oil slick. And today, the temptation to design more or less everything according to prescriptive and broken-up technologies is so strong that it is even applied to those tasks that should be conducted in a holistic way. Any tasks that require caring, whether for people or nature, any tasks that require immediate feedback and adjustment, are best done holistically. Such tasks cannot be planned, coordinated, and controlled the way prescriptive tasks must be.

When successful, prescriptive technologies do yield predictable results. They yield products in numbers and qualities that can be set beforehand, and so technology itself becomes an agent of ordering and structuring. (This aspect of technology is easily underestimated by those who see technology as mainly the application of scientific knowledge to real-life needs and problems.) The ordering that prescriptive technologies has caused has now moved from ordering *at* work and the ordering *of* work, to the prescriptive ordering of people in a wide variety of social situations.

For just a glimpse of the extent of such developments, think for a moment about the new "smart" buildings. Those who work in the buildings have a card with a barcode that allows them to get into the areas of the building where they have work to do but excludes them from anywhere else. Here we have what Langdon Winner, in his book *The Whale and the Reactor*,[13] calls so nicely "the digitalized footprints of social transactions," since the technology can be set up not only to include and exclude participants, but also to show exactly where any individual has spent his or her time. You could — just in a flight of fancy — imagine what would have happened if Adam and Eve had not lived in a garden but in a smart building. The divine designer would probably have arranged it so that they never saw apples. But, joking aside, prescriptive technologies eliminate the occasions for decision-making and judgement in general and especially for the making of *principled* decisions. Any goal of the technology is incorporated *a priori* in the design and is not negotiable.

To sum up, then: As methods of materials production, prescriptive technologies have brought into the real world of technology a wealth of important products that have raised living standards and increased well-being. At the same time they have created a culture of compliance. The acculturation to compliance and conformity has, in turn, accelerated the use of prescriptive technologies in administration, government, and social services. The same development has diminished resistance to the programming of people.

There are several concepts which will appear and reappear in my discussion of the real world of technology. The notion of scale is one of them. Economies of scale are intimately connected with advances in industrial production. Arguments extolling the benefits of economies of scale were as frequently heard in discussions about industrialization and the use of machines in nineteenth-century Britain as they are heard now when mergers and takeovers are debated.

Scale was a term initially used solely to indicate differences in size: It was felt that the scale of a cathedral had to be different from that of a village church; the manorhouse was built differently in scale from the cottage of a labourer. Large scale signified greater prestige, rather than improved functionality. Only when the notion of scale was applied to production technologies was an increase in scale perceived as an increase in effectiveness, and therefore as inherently beneficial to the factory owner. From being a measure of comparison, the notion of scale moved to being a figure of merit. The value-laden phrase "bigger is better" — without ever stating for *whom* it is better — comes solely out of a production-centred context.

Underlying the different uses of the concept of scale are two different models or metaphors: one is a growth model, the other a production model. Models and analogies are always needed for communication, and in order to be useful tools for discussion, models and metaphors need to be based on shared and commonly understood experiences. The features of growth, the very processes and cycles of growing, the diversity of the components of each growing organism, all have resonated through the historical written records.

Much folklore carries a prejudice against the overgrown. The giants in fairy tales are often stupid, while it's the little people who are resourceful and quick. Common experience teaches that the world is made up of things of different but appropriate sizes, and in all growth models this is acknowledged — particular sizes are appropriate for particular functioning entities or species. Implicit in any growth model is the notion that size and scale are *given* relative to any particular growing organism.

Size is a natural result of growth, but growth itself cannot be commandeered; it can only be nurtured and encouraged by providing a suitable environment. Growth occurs; it is not made. Within a growth model, all that human intervention can do is to discover the best conditions for growth and then try to meet them. In any given environment, the growing organism develops at its own rate.

A production model is different in kind. Here things are not grown but made, and made under conditions that are, at least in principle, entirely controllable. If in practice such control is not complete or completely successful, then there is an assumption, implicit in the model itself, that improvements in knowledge, design, and organization can occur so that all essential parameters will become controllable. Production, then, is predictable, while growth is not. There is something comforting in a production model — everything seems in hand, nothing is left to chance — while growth is always chancy.

Production models are perceived and constructed without links into a larger context. This allows the use of a particular model in a variety of situations. At the same time such an approach discounts and disregards all effects arising from the impact of the production activity on its surroundings. Such *externalities* are considered irrelevant to the activity itself and are therefore the business of someone else.[14] Think of a work situation, a production line. There are important factors — such as pollution or the physical and mental health of the workers — which in the production model are considered other people's problems. They are externalities.

We know today that this discounting of context and the failure to consider external and interactive effects are, in fact, a ticket to trouble. We know that the deterioration of the world's environment arose precisely from such inadequate modelling. Processes that are cheap in the marketplace are often wasteful and harmful in the larger context, and production models make it quite easy to consider contextual factors as irrelevant.

It is worthwhile stopping for a minute to see whether we ought not to think far more in terms of growth models rather than production models, even though today production models are almost the only guides for public and private discussions. It is instructive to realize how often in the past the production model has supplanted the growth model as a guide for public and private actions, even in areas in which the growth model might have been more fruitful or appropriate. Take, for instance, education. Although we all know that a person's growth in knowledge and discernment proceeds at an individual rate, schools and universities operate according to a production model. Not only are students tested and advanced according to a strictly specified schedule (at least at the university where I have taught for the last twenty years), but the prospective university students and their parents are frequently informed that different universities produce different "products." Within all production activities, complaints of users are taken very seriously, and those complaints can often result in modifications of the production line. Thus, adverse comments from captains of industry may result at universities in the establishment of extra courses such as entrepreneurship or ethics for engineers, spelling for chemists, or fundraising for art historians. The implication is that choosing a particular university, following a particular regimen, will turn the student into a specifiable and identifiable product.

Yet all of us who teach know that the magic moment when teaching turns into learning depends on the human setting and the quality and example of the teacher — on factors that relate to a general environment of growth

rather than on any design parameters set down externally. If there ever was a growth process, if there ever was a holistic process, a process that cannot be divided into rigid predetermined steps, it is education.

Similar arguments for not supplanting growth models with production models could be made in the case of health care and in many of the applications of the new biotechnologies. For me the most frightening incursions of production technologies and production thinking have happened in the new human reproductive technologies. The close monitoring of the fetus and some of the invasive prenatal technologies can only be considered as quality-control methods, with the accompanying rejection of substandard products.

On a quite different plane there is another very interesting contrast between the growth model and the production model. This situation occurs in the area of demography and population growth. You'll remember that before the Industrial Revolution there was a fascination with numbers and population increase. It was a time when people like Malthus, Ricardo, and Adam Smith were preoccupied with the growth in numbers of the lower classes.[15]

Now, oddly enough, there was no such preoccupation with the growth in numbers of the rich. Queen Victoria, for instance, had nine children. The youngest was three when the Prince Consort died. She had thirty-nine grandchildren, and none of her children or grandchildren died in infancy, as was common at the time. The drain on the public purse, one would think, of thirty-nine grandchildren of Queen Victoria was substantially larger than of thirty-nine grandchildren of wives of miners or farmers. Nevertheless, it was the growth in numbers of the poor that fascinated economists and statisticians. Since then "demography" has become an area of legitimate study.

Today population forecasts are based on extensive and reliable data. Issues related to population growth and the resources required to sustain an increasing number of people on earth are being discussed on the basis of reasonably factual information and developed methodology. However, no such demographic base exists for the world's growing population of machines and devices, as I have stressed on earlier occasions.[16] This absence is a telling phenomenon, since appropriate data bases could be generated if there were the political will to do it.

The automobile, for instance, has been part of many societies for the last hundred years or so. The support structures for the car population are in place — the production of gasoline and its delivery by service stations, roads and bridges, car ferries, and parking garages. We know about smog and toxic emissions, resource limitations, and transportation problems. Yet in spite of all this, birth control for cars and trucks is not an urgent agenda item in any public discussion. Useful statistics are hard to come by, since nobody does the type of nose-counting for machines and devices that is commonly applied to people. Lots is known about the life expectancy of people in different parts of the world, about the caloric requirements for their well-being, and so on. Almost nothing is known about the global energy need of devices or about their lifespans. China can embark on a rigorous one-child-per-family

policy for the sake of the country's future, and in general that policy has been approved by the world community. But where in North America, western Europe, or Japan is there serious discussion on the political level about, for instance, the need for a one-*car*-per-family policy for the sake of the country's or the world's future? Now may be the time to take machine demography seriously and enter into real discussions about *machine* population control.

The real world of technology seems to involve an inherent trust in machines and devices ("production is under control") and a basic apprehension of people ("growth is chancy, one can never be sure of the outcome"). If we do not wish to visualize people as sources of problems and machines and devices as sources of solutions, then we need to consider machines and devices as cohabitants of this earth within the limiting parameters applied to human populations.

I began this talk with a look at technology as *practice*. The common practice of particular technologies can identify people and give them their own definition; it also identifies and limits the content of what is permissible. I moved on to considerations of the division of labour and stressed the importance of prescriptive technologies. These prescriptive technologies that now encompass almost all of technological activity are, in social terms, designs for compliance, and in this I find one of the most important links between technology, society, and culture. I illustrated this with some examples from ancient China. And I touched on the concept of scale. The change in the notion of scale from a simple parameter of comparison to a parameter of merit allowed me to discuss the presence of two different models — a growth model and a production model — present throughout history. Just as prescriptive technologies have, in the real world of technology, overwhelmed holistic ones, so have production models now become almost the only pattern of guidance for public and private thought and action.

The unchallenged prevalence of the production model in the mindset and political discourse of our time, and the model's misapplication to blatantly inappropriate situations, seems to me an indication of just how far technology as practice has modified our culture. The new production-based models and metaphors are already so deeply rooted in our social and emotional fabric that it becomes almost sacrilege to question them. Thus one may question the value of people (to go back to the issues of human demography I just mentioned), but not the fundamental value of technologies and their products.

But question we must. It is my view that today's real world of technology is planned and run on the basis of a production model that is no longer appropriate for the tasks that we want to undertake. Any critique or assessment of the real world of technology should therefore involve serious questioning of the underlying structures of our models, and through them, of our thoughts. To quote Kenneth Boulding again:

> We cannot walk before we toddle,
> but we may toddle much too long
> if we embrace a lovely Model
> that's consistent, clear and wrong.[17]

II

I called these lectures *The Real World of Technology* for two reasons. One is that I wanted to pay tribute to C. B. Macpherson and his 1965 Massey Lectures, "The Real World of Democracy." I intend to look at technology the way Macpherson looked at democracy, as ideas and dreams, as practices and procedures, as hopes and myths. The second reason is that I wanted to discuss technology in terms of living and working in the real world and what this means to people all over the globe. This is the "real" part in the title, and this is what I wish to address now, having spent some time in the first talk on certain aspects of technology as practice.

When I talk about reality, I'm not trying to be a philosopher. I think of reality as the experience of ordinary people in everyday life. There are different levels of reality, and I