The Future for Innovation

Roles of scientists and engineers will come together as realm of unknown is probed

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I will treat the problems involved in searching for new technologies. I will consider four topics:

1. The invention itself as a nucleus for the future process and products.
2. A number of new technologies.
3. The resistance of society to accept these new technologies.
4. A plea for a European policy.

Since his first appearance on earth man has learned to live with change — changes having a regular succession such as birth and death and the rotation of the seasons; changes wrought by revolution and giving rise to different cultures; changes having a certain historical pattern, as the philosopher Arnold Toynbee described it in his comprehensive work "A Study of History" in the four chapters entitled "The Genesis", "Growth", "Breakdown" and "Disintegration of Civilizations".

History teaches us further that innovations have always played a great role in changes. Man has been constantly searching for new technologies to improve his living standards, the ultimate goal of this process of renewal being his human survival. Many minds have been engaged in the study of the renewal process. It has been necessary, however, to acknowledge that no two situations contain elements sufficiently comparable to allow the derivation of a common pattern between them.

Four Factors

There are, nevertheless, four factors which can be identified as having influenced innovation:

1. An innovation can occur as a result of deliberate attempts to develop it. An example of this is seen in the work of Edison, who in his attempts to improve the weak light of the arc lamp, after much inspiration and perspiration, produced the incandescent lamp.

2. The attempt to find one thing can lead to the discovery of another. An example of this can be found in the work of Oersted, who, in endeavoring to prove that a compass needle is not affected by an electric current, proved precisely the opposite and gave birth to the electromagnet.

3. Unrelated developments can have a decisive effect of the main event. An example of this is the development of the horizontal loom, which made it possible to mass produce linen. The rag waste thus produced formed the basis for a new process for paper production.

4. Physical and climatological change. An example of this is found in the work of Dr. John Gorrie. He invented refrigeration and air conditioning because he erroneously thought that the disease from which his patients were suffering was caused by the hot summer and the rotting vegetation.

In addition to the factors just mentioned communications have also played a very important role in innovation. In the development of communications between innovators three historical periods have made their own valuable contribution: the medieval industrial revolution, in which after the invasions during the tenth century it was possible to found a closely knit, secure communications network; the art of printing in the 17th century; and the more widespread development of communications in the 19th century. Finally, a fourth period has to be added — the worldwide scale of communications at the present day with the universe as the unrestricted area.

There is yet another aspect of innovation deserving of attention. That is the manner in which science and technology have mutually influenced each other over the ages. It can be said with certainty that a fundamental fusion between science and technology was reached when Newton published his "Mathematical Principles of the Natural Sciences" in 1684. This established the pattern to be followed by technology. And since technology has been developed to a high level in the guilds, the cooperation between science and technology led to the industrial revolution.

Energy Situation

The present situation will be familiar to you. The energy crisis has plunged the industrial countries into great difficulties. Developing countries are competing with us in our own products. We are advised to replace our product range with high-value products. Research establishments are being increasingly called upon to direct their efforts more to those sectors of society where innovation is essential. The responsibility for innovation is laid principally on the shoulders of small concerns which by virtue of their flexibility and mobility play a large role in the renewal of products and processes. Their innovative character, therefore, makes them very important for the national economy. An analysis of the situation reveals, how-

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ever, that the present world impasse is so great that only very large concerns such as the multinationals can resolve it. Hence, the industrial countries now face a great challenge. On the one hand, they will have to solve their own problems by means of high-value replacement products and, on the other hand, they will have to strive to bolster up the industrial potential of the developing countries in order to absorb the population explosion.

Searching for new technology will, therefore, not only entail the development of very high-value technologies but will also have to stimulate an innovative approach to the selection of "appropriate technologies" — not only for developing countries but also for our own environment. And, in so saying, I have arrived back at the point which I made at the outset: once again we shall have to be prepared to adapt ourselves to the challenges of innovation. This is a matter of grave concern to me as a scientist; let me tell you why. Let us look at science itself, which, after all, has provided the basis for many an innovation. In the 19th century it was still capable of being comprehended by the individual but in the 20th century it has become so complex that no one individual can any longer fully comprehend it in all its manifestations. Research is now a multi-disciplinary affair. And herein rests my concern.

In universities, particularly, but, alas, in industrial laboratories also, research fields, particularly those entailing studies in depth, have attained a high degree of specialization. This development has had two consequences:

1. Many specialists who have to cooperate in multidisciplinary work are not adequately equipped to do so.

2. The gap between fundamental science and innovation is consequently increasing.

This is the dilemma of science — a degree of specialization necessitating deep and prolonged study, on the one hand, and, on the other hand, the immobility and inflexibility which this produces.

For scientists mental and physical mobility and flexibility are absolute "musts". Few scientists are geniuses. If genius has not revealed itself by the age of 30, it probably never will. Society can afford to let the ordinary scientist devote a few years to directions of his own choosing, but should then expect him either to apply his skill to the transfer of technology or to do research on the subjects of his paymaster. Let me give you some examples.

Imperial chemical industries have a policy that every scientist ought to leave the central laboratory by the age of 35. Ideally to launch an innovation which he has discovered.

A second example: The Medical Research Council (MRC) in the U.K. sponsors some of the finest medical laboratories in the world, largely because it has little hesitation. When their scientists have finished doing useful work, work is found elsewhere.

Mobility and flexibility, when forming the guarantees applied to multidisciplinary work, serve as the key with which to unravel the complexities arising in various aspects of scientific and technological collaboration and to transform them into a clear and well-ordered system.

Since there is a need for a more multidisciplinary approach to many sciences, we must encourage professors and other research workers at the universities to penetrate the historical walls of their faculties. We must also encourage able young scientists who are eager to work on the problems of society to join university staffs on a temporary basis and in this way act as a bridge between the university faculty and industry. We also have to encourage young scientists to travel as much as possible during their time at the university.

I should like to cite medical technology as an important example of the multidisciplinary approach. Clearly, the tremendous advances made in medicine have been the result of longstanding cooperation between the medical and the natural sciences. Studies of the biological, chemical and physical properties of matter have led to the development of very advanced medical equipment. In my opinion, this has been achieved as a result of the cooperation between engineer and doctor, both of whom adopt a practical approach and, moreover, have to work continuously at the problem-solving level. An example is the materials of construction used for the replacement of hip joints and other structural components of the body. The complex problems involved in finding a suitable material and making allowances for the body's rejection mechanisms are today solved on the basis of cooperation between people of different backgrounds. However, the costs of these operations are still high and further research is needed in order to reduce them.

The growth of this new technology, involving a concentration of knowledge of great breadth and depth, has also led, as a result of the cooperation between university and industry, to the creation of new products. In this context, the problem has been to bridge the gap between fundamental research and clinical applications. For example, if a heart valve is developed in a department of a technical university, this has first to be evaluated on the basis of its anatomical, mechanical and surgical aspects. Only when these results are found to be satisfactory can the valve be put on the market. In the Netherlands a coordinating body — the DUMEG (Dutch Medical Export Group) Centre — between the universities and industry has been set up for this purpose. It has been established that the world market for medical technology is worth something like 8,000 million guilders per year. Dutch industry accounts for 18% of this figure.

Industrial Robot

A second example of the multidisciplinary approach is the industrial robot, which is being increasingly applied and has, for instance, in the production lines of Japanese motor manufacturers succeeded in effecting a breakthrough on the European and American markets. Many specialized fields are involved in the development of the robot, such as those of mechanical, microelectronic, measurement and control, materials and welding engineering. In the development of robots there are two central objectives — to increase industrial safety and to develop the sensory perception (i.e. the powers of observation) of robots. To increase industrial safety the new generation of robots will be increasingly equipped with diagnostic devices for the very rapid detection of the causes of malfunctioning. This will ease and speed up the job of the maintenance man. The development of sensory perception will enhance machine intelligence, the robot being equipped with the senses of feeling and sight.

The problem with the application of robots is in so many cases the age of the machine inventory involved. For instance, in the United States metal industry 70% of the machines are more than 20 years old. And yet an article recently published in *Business Week* makes it clear that, although only 3,000 or so robots are at present installed in the United States, for 1990 a market of 200,000 robots is forecast.

A third new technology development is that of microelectronics. Although the basic constituents, the chips, were themselves created as a result of multidisciplinary cooperation, microelectronics will now in its own turn be increasingly operating as a key factor in many new multidisciplinary innovations. Consequently, microelectronics will bring about drastic changes in our society and, hence, stimulate a reorganization of many branches of industry. Well-known examples are found in the "electronicization" of the gear-manufacturing industries, namely those engaged in the manufacture of watches, clocks, cash registers and safes. Any manufacturers in this field who have not kept abreast of developments in electronics have now gone out of business. Microelectronics is expected to break into at least six new fields in the next few years (if this has not already happened), namely those of telecommunications, information processing, domestic appliances, product control, welfare services and instrumentation.

The application of microelectronics is attractive because as an up-and-coming technology it has many advantages such as a low energy consumption, environmental compatibility, low costs and a low space requirement. However, it also constitutes a threat to privacy and employment, although opinions are strongly divided in the latter respect. The potential for the application of microelectronics is unlimited, certainly if it is considered in combination with communication and computer techniques. Examples in this regard are the telephonic transmission of pictures, the electronic transfer of payments, translation capsules, electronic toys and the domestic computer. Enormous growth markets are expected for data-processing equipment, whose current turnover of 100,000 million guilders will have been doubled by 1990. Furthermore, as a result of the application of glass fibers in transmission media it will be possible to conduct hundreds of thousands of telephone calls at once. By about 1985 the number of telephone appliances in the world will be double the present 450 million.

Adaptation

We shall only be able to adapt ourselves slowly to these lightning developments. Consequently, the assimilation of all this equipment into our domestic and working lives can above all be expected to entail a great degree of social innovation in the near future. This could perhaps mean more jobs for the excessive number of overtrained sociologists.

The last example which I wish to mention is that of biotechnology, whose breakthrough can be expected to follow that of microelectronics at the end of the 1980. Biotechnology is a multidisciplinary collective term for the application of biological processes or, put another way, the integrated application of microbiology, biochemistry and chemical process technology. Hence, biotechnology is a paramount example of many scientists working together. Biotechnology will be much in demand as an aid in remedying many social ills. Let me give you a telling illustration of this.

At the TNO Conference on Biotechnology held in Rotterdam at the end of March 1980, which had been given the title "A Hidden Past, A Shining Future", some of the speakers made a number of strong statements. I shall quote a few of them:

— Within a few years the petrochemical era will be replaced by the microbiological era in both the chemical and energy supply fields.

— The strength of biotechnology lies in its potential uses in four world problem areas (energy, food, environment and raw materials), uses of a rather different character from those of pharmacy.

Those who follow biotechnology closely will recognize much truth in these statements. Even now developments are in sight involving the production of insulin and antibiotics, the distillation of alcohol and the conversion of chemical waste into plastics, all through the agency of bacteria. A particular breakthrough for diabetes is the production of insulin within the body by means of bacteria.

Let us hope that in the further development of biotechnology a proper balance continues to be maintained between risky manipulations with the DNA molecule and the much more intriguing innovations which can be expected to contribute greatly to the solution of the many existing human and social problems. I can add even more examples of new technologies to the list of those already mentioned, since the more advanced the technology the more the knowledge that is revealed; knowledge generates knowledge; innovation generates innovation. And, armed with this knowledge, man sets off in search of raw materials to every corner of the earth, possibly even voyaging to distant planets in search of any possible fellow human inhabitants of the universe. Can such developments continue at the same tempo? I do not believe so.

There is an increasing tendency in our society to view new, often very complex, technical innovations with grave suspicion. The search for new technologies is now hampered by social protests against innovations which threaten man's social and living conditions, such as protests in the spheres of nuclear energy and environmental pollution. Science and technology are being called to account — "Technology on Trial" is what the organization for economic cooperation and development (OECD) calls it in the title OECD gives to a report which it published. The consequences are already making themselves felt in legislation; the development of nuclear power stations is being held back by pressure groups. Offenses against the environment, such as poisoning the soil by illegally dumping chemical waste in future housing development areas, inculcate a fear of the unknown in the layman. The search for new technologies will first and foremost, therefore, have to take social resistance into full account. This in its turn gives rise to the problem of the choice of appropriate technologies. What is more, the philosophy of "the sky's the limit" in space exploration, which was upheld by financiers for prestige reasons, has had to be abandoned. All too limited budget resources will also dictate the choice of the future course to be pursued.

Let me illustrate these problems:

Do we want to develop further research into projects with an ethical side to them, such as research into further manipulations of the DNA molecule and chromosomes in order to probe further into the mystery of man; or do we use the money to develop, for example, a portable kidney apparatus for dialysis at home or even on holiday?

What will be the effect of the introduction of view data, a television system which can give you in your chair at home all the information you want on any subject? At an exhibition I was shown within 10 seconds the addresses of the best new French restaurants in London. How will this affect people in the service sector?

What will be the effect of micro-processors on our daily life? Will the present mass introduction of these minicomputers lead to unemployment among industrial workers? What shall we do if strategic materials from Rhodesia or South Africa are no longer available? Are we going to fight a war to get them or are we going to obtain them from manganese nodules lying at a depth of 5-10 km on the ocean bed? Can we go on linking computers in order to obtain more information? What about our privacy?

I know that a fool can ask more questions than a wise man can answer. Nevertheless, the scientist and the engineer will also be obliged to look into these questions before developing new technologies; if they do not, they will involve themselves in conflicts with society and, as a result, with each other.

In this paper I tried to indicate the lines along which new technologies are developing. In doing so, I pointed out a number of important fields, particularly those of microelectronics and biotechnology, in which there will be a major breakthrough of new technologies. I have also drawn your attention to the fact that the community, largely inspired by a fear of the unknown, will react to the development of these new technologies with great restraint.

This is nothing new, historically speaking. You may perhaps still be able to recall the case of the Luddite riots, which broke out when in about the year 1800 hand looms were replaced by mechanical looms in England. Despite the fact that on that occasion the workers destroyed the new machines, the march of progress could not be halted.

Present conditions, however, call for the exercise of even greater caution because in the course of time visible and, hence, perceptible techniques have become invisible. We can put this another way by saying that we are living in an era when a chip, which contains innumerable wiring circuits, is so minute that it is virtually invisible on the photograph of a fingertip.

And yet it is my opinion that our future lies in industrial activity — an activity which in its turn will be a necessary guarantee for our future survival.

Finally, I would like to say a few words on European policy with respect to the development of new technologies. After the search for new technologies, follows obviously the development of new technologies. For Europe it is very important, that a European policy will be established. In particular Mr. Davignon, responsible for the industry policy in the European Committee, stressed this recently at a press conference. He pointed out that Europe in comparison with the United States and Japan is terribly behind in the field of information technology and telecommunication.

A striking example of this is that the European Community only produces 6% of all integrated circuits for microelectronics. Davignon proposes therefore to support industry yearly with a subsidy of 275 million guilders per year from now till 1985. In 1985 our share of the world production could be 12%. In spite of this support only half of our needs will be covered. The European Committee has therefore asked the "Ministers of the Nine" to promote that the national programs will be brought together in a European context. This approach and other efforts to come to a European policy will ask a great deal of energy and cooperation from all of us.

I'm convinced that you as international organization have been working on this since the institution of LES.