Quantity of goods or quality of life?

The engineer's dilemma

by MEREDITH THRING

Technology can be used to create robots and put people out of work; it can also be used to alleviate the suffering of the world's poor. Some engineers see their task as solving technical problems, while others focus on the needs of people. Here a noted British authority describes his changing perception of the engineer's role.

My 27 years as a professor of engineering have taught me that the engineer has a much greater effect on the lives of ordinary people than that more ubiquitous figure, the medical doctor. For while the doctor is concerned with providing remedies for people's physical (and sometimes mental) ailments, the engineer is the person who creates the good and the bad things that originally stemmed from the industrial revolution. The engineer's creations range from brain scanners to nuclear weapons, and from convenient materials to robots. So why, I wonder, have doctors had to take the Hippocratic oath for 2400 years, while engineers still work for money, with no real ethic other than giving their employer or client what he has paid for?

My experiences have had profound effects on my thoughts as to the humanity that engineers should embody in their approach to their work. Perhaps they should follow the line of thinking that I proposed in 1971 in an article in *New Scientist* entitled "A Hippocratic oath for applied scientists". The shortened version of the oath was, "I vow to strive to work towards the coexistence of all human beings in peace and human dignity with all the necessities for a self-fulfilling life and freedom from fear, stress, ugliness, pollution and noise."

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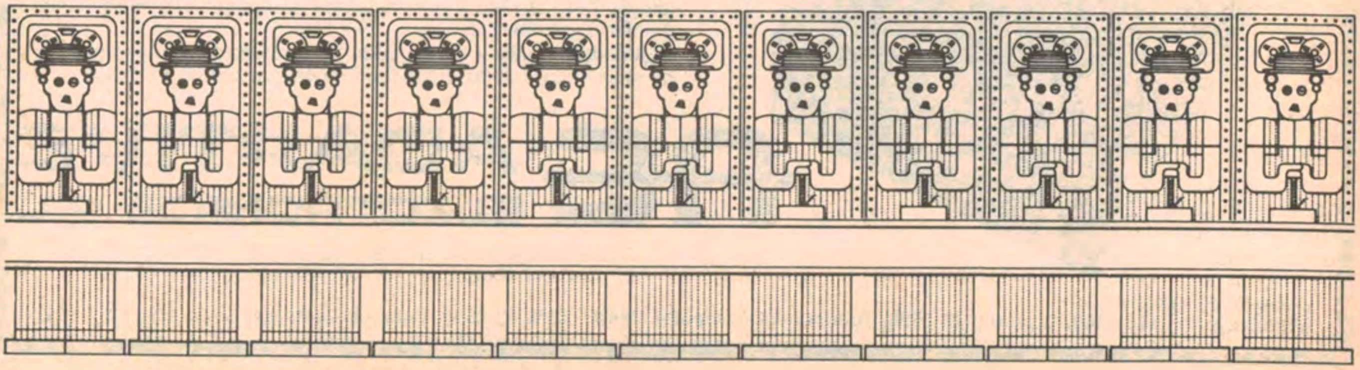
Perhaps the most striking consequence of my studies of engineering's effects on human life has been the change in my attitude to robots. From about 1955 to 1975 I was experimenting on the components of a sophisticated robot that would relieve humans of drudgery in the home, office and factory. In 1960 I suggested that we could, in 10 years, develop a mechanical housemaid that would do all the routine jobs in the house and cost no more than a family car. In April 1964, I developed the idea further, proposing a robot slave that could be programmed to scrub, sweep and dust, wash up, lay tables and make beds. It was to have a memory for instructions and a limited degree of intelligence so that it could adapt to some objects being out of their normal positions.

My students had already built the stair-climbing machine I had designed, and later a battery-operated prototype wheelchair for carrying handicapped people up kerbs and staircases. These designs resulted from the keen sympathy I felt over the frustration of highly educated women and their husbands having to spend so much time doing the daily chores necessitated by our wish to live in pleasant homes. The work culminated in our developing a table-clearing robot which we demonstrated in 1969 at the British Association for the Advancement of Science meeting in Dundee. The robot could work within the two horizontal dimensions of the table and could sense the diameter of the objects on a rectangular table.

We also built a fire-fighting robot in 1962. This robot navigated its way round a "track" using signals from a gyro compass and measuring distance by wheel-rotation. It left the track when it "saw" a fire and extinguished the fire when its "finger" sensed the flame. The idea was to develop a fully automatic night watchman that could travel around a warehouse and look out for a fire. We also studied a possible robot storekeeper.



The benefits of this work, we thought, would be:

- Avoiding drudgery and boring repetitive work.
- Eliminating danger and discomfort at work.
- Increasing available resources and reducing wastage (this is by no means an essential consequence of robot development: a skilled craftsman uses less power and is much more economical with materials, but a robot will spoil less products than a careless, tired or bored human).

However, over the past 10 years I have become increasingly concerned about several dangerous consequences of concentrating research on robots. The primary gain from installing industrial robots is that they cut labour costs; in other words they reduce the number of human employees.

We have reached the point in the developed countries where we must expect higher unemployment if we want to increase productivity. There are a number of reasons why this is so. One is that fossil fuels and other mineral resources are no longer considered to be infinite, and, therefore, it no longer makes sense to build obsolescence into industrial goods. Another reason is that people are no longer so easily satisfied. This leads to what I call the robot fallacy: "It is desirable to employ a robot rather than humans if it reduces production costs." The fallacy is apparent when one considers that each unemployed person costs the country on average $200 a week and most humans prefer to feel that they are doing something useful than to be paid for being idle.

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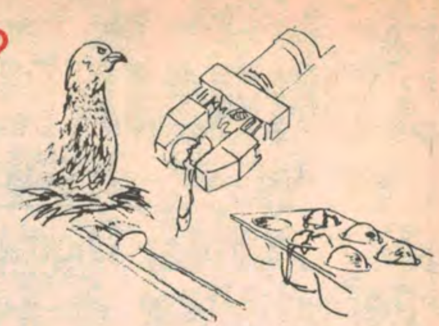
For these reasons I have abandoned my work on industrial robots, where the primary aim is to displace human labour. I now work only on applications where the aim is to enable someone to do the job he does now without actually exposing his body to danger or discomfort; or where we need to amplify or diminish his skill and strength. A good example is "telechirics", the name for artefacts that allow people to work artificial hands and arms and to operate machines in hazardous or unpleasant environments as if they were there, while they are in fact in comfortable and safe conditions. Telechirics provides such good tactile, power and visual feedback that a person can apply his skill remotely. Curiously, telechirics was first developed when engineers thought that they could build nuclear-powered aircraft and wanted something that could go into one if it crashed. Later telechirics was used in space research. It can clearly also be of immense value in mining (especially of dangerous minerals such as asbestos or uranium), and for handling explosives, firefighting, bricklaying in hot furnaces and many other tasks including surgery.

It is 20 years since the first commercial non-adaptive robot was sold and there are still only 20,000 robots in the world, more than half of them in Japan. There are more than one thousand million workers in the world; that means one robot for every 50,000 people. As world unemployment rises, I believe that the robot population will climb to perhaps a few per 100,000 people and that they will be doing only dangerous and uncomfortable jobs (such as paint spraying), tasks that call for repetitive accuracy and manually demanding jobs such as sheep shearing.

Too great a concentration on developing robots also diverts skilled engineering effort from a vastly more important human problem – helping people in poorer nations. Sir Harold Hartley first drew my attention to this

Robots—are they worth developing?



when he chaired a meeting at which I read a paper on the "domestic revolution". I talked about the domestic and the fire-fighting robots, among other things. He said to the meeting, "I felt a little doubtful about his saying that the objective is not raising the standard of life but creating more happiness, because after all he was thinking of was this country and the United States and there are so many other countries where the first duty of applied science is to try to raise the standard of living." This remark set me thinking. Three years later in my Cantor lecture of the Royal Society of Arts I said, "The more developed countries have a moral responsibility to find a technological way of aiding the less developed ones to achieve a satisfactory standard of living for all their peoples. The peace of the world depends on this." My feelings on this matter were enormously strengthened when I was a member of a UNESCO team of ten people who visited Bangladesh in 1979 and I walked through hospitals with hundreds of children suffering diseases resulting from malnutrition.

My work on robots that can sense something and respond, and on the way in which people do the enormous variety of tasks for which their hands are trained, has led me to conclude that an artefact cannot match the sophistication of the trained human system at a price that does not take away resources from vast numbers of people. It is of course possible (and indeed it has already been done in Japan) to make a robot with some limited sensory adaptiveness to do a small variety of fairly simple tasks. But imagine designing a robot with hands that could fold a sheet, thread a needle or cuddle a baby. That is how advanced a human's "system" is and it takes many years of practice and intelligent modification of behaviour to acquire these apparently simple skills.

I have therefore been forced to the conclusion that we will waste most of the inventiveness and skill now being devoted to developing robots. This is both because unemployment will inevitably rise to socially unacceptable levels in the developed countries, including the most successful ones as well as Britain, and because the only way to avoid world war is for the developed countries to devote a significant fraction of their engineering skill to solving the basic problems of the poor countries. Clearly, tensions in the world — caused by rising populations, increasing poverty and disasters, while the rich countries are consuming the world's oil — will lead to a greater danger of war if they are not checked within another generation. And no amount of the most sophisticated robots will help us in a nuclear holocaust.

Another theme to which I have given continual attention is the attitude in Britain towards industrial innovation and applied science. At first I was solely concerned by the tendency in this country to reject new things "until the foreigner had burnt his fingers first" and to spend most of our limited research funds on "big physics" rather than engineering. This led me to join in discussions about establishing a British society of top engineers with the task of making "far-sighted and wise decisions as to the direction in which invention and development should go". That was in 1966. Then in an article in *Nature* in 1967 I suggested there should be a British Academy of Engineering, much like the one set up in the US.

I was delighted some 10 years later when, in 1980, the Fellowship of Engineers was set up in this country.

My views about what is the right long-term policy for engineering in Britain have steadily moved away from those of a blind follower of progress for its own sake. Originally, like almost everyone else, I believed in the continuing exponential increase in the speed of travel, output of steel and electricity, standard of living, and so on, although I was always keen on achieving the result with as little fuel as possible. In 1968 I expressed concern with our lack of young inventive engineers because of academic snobbery, bad career advice and the image of engineers as socially irresponsible ("Getting to grips with technology" *New Scientist,* vol 39, p 644). I criticised our tendency to say of a new idea that it would not work, or it would not be economic. And in 1969, I proposed a workshop in which inventions should be given as good a chance as new ideas are in pure science, provided they satisfied three criteria. These were: that the idea was not contrary to the known laws of science; it was not contrary to the interests of the individual human being; it appeared to be novel.

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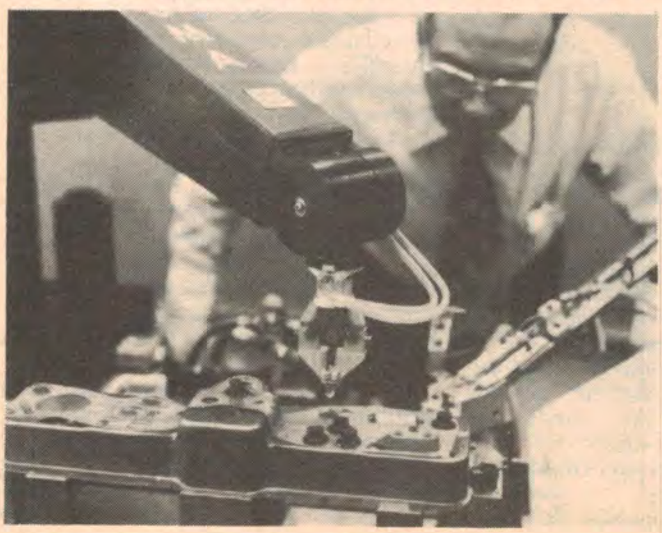
The second of these three criteria has become steadily more important to me. I have come to feel that most of the dangers to our civilisation stem from decisions taken on a short-term basis. We take avoiding action because a problem looms up — such as pollution, violence, rising oil costs, unemployment or inflation — but by being short-term, the actions rapidly worsen other problems.

A society that bases its measurements of success solely on the acquisition of status symbols must be self-destructive because there are not enough resources to last for ever. But I remain an optimist because, where lecturing to many thousands of young people, I have found them prepared to take a long-term view and to accept that standards of living will level off while creative self-fulfilment will improve the quality of life.



Work on robots aims to match skills of trained human beings. In this laboratory demonstration a PUMA robot inserts a light bulb in a dashboard panel.