PHILOSOPHICAL TRANSACTIONS OF THE ROYAL SOCIETY A MATHEMATICAL, PHYSICAL & ENGINEERING SCIENCES

General Discussion

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General discussion

In opening the discussion, Dr Williamson said it was a valuable opportunity for an interchange of ideas on all aspects of manufacturing technology and the developments that might be expected in the next two decades. He hoped, for instance, it would cover the reasons for the paralytically slow rates of change in manufacture compared with those which are technically feasible. Many factors are involved here, ranging from the structure of companies to accounting procedures and individual attitudes, but they all added up to a barrier to beneficial change which could destroy our economy if it is allowed to persist. He asked if there were factors which had not so far been identified which could modify or nullify the patterns of change which speakers had suggested. Would forecasts in future be made by projection of past trends, or by means of causal relationships as Dr Young had suggested?

Our industrial survival depends on major technological innovations. With one brilliant invention, Sir Alastair Pilkington had changed the world plate glass industry. How can we ensure that such innovations occur? New and successful manufacturing systems could change the entire structure of manufacturing industry. Should this be our objective, or are we going to restrict our thinking to minor modifications of what already exists, and leave the great leaps to others?

We appear to be entering a phase of near revolution in social attitudes to work and in particular in people's expectations and aspirations. Can we be more precise about the forebodings which some speakers have expressed? Can we make jobs more interesting? How much has the cell system to offer in correcting anti-human trends?

There is nothing inevitable about the developments that have been suggested to the conference. Manufacture in the 1980s will be what we, as members of society, care to make it. We should not allow computers to determine our future; they are merely powerful tools for us to use. Changes which involve vast sums of capital are obviously limited in their rates of application, but sweeping and effective changes can stem from new concepts of organization. These are limited only by lack of imagination.

If the desire to shape events and not to be shaped by them penetrates into the chilly fastnesses of boardrooms and cabinet rooms then perhaps we have the engineering and organizing ability to make the 1990s' events happen in the 1980s, and to start in the 1970s.

Mr D. J. Falvey (*Group Technology International, George Road, Birmingham* 15) said that he subscribed to the philosophy propagated by J. M. Keynes that man could control his own destiny. The purpose of the conference was to consider what could be done in the next 20 years. He would concentrate on the question of size and volume and the so-called economies of scale. At one end of the spectrum was conventional batch manufacture which was discredited. The economic batch concept leads to larger batches being produced than are needed; delivery dates are unreliable.

The solution may lie in the cell system, which breaks up the volume of work to be done into smaller and more manageable groups, thus ensuring closer and more effective control. Parts are made from start to finish by a small group of people who are thus involved in their jobs. This will cut down the boredom which is responsible for a great deal of present labour unrest. Furthermore, it involves no capital expenditure; it demands only a change in attitude and ideas and an investment in organization and methods.

He said he also wished to challenge Dr Finniston's thesis that increasing size in the steel industry inevitably leads to lower costs of production. It should be examined in the light of the total social and industrial environment; for instance, what was true of steel works on the Continent was not necessarily true of those in Britain. Rather than plan a very large integrated works, he would prefer the British Steel Corporation to consider mini steelworks which had several advantages. Beyond a certain scale of steelworks, he suspected, there were diseconomies of scale and there was no cost advantage to be obtained beyond a size of about seven million ingot tonnes.

The British Steel Corporation is contemplating a target for expansion of 28 million to 36 million tonnes. If the figure turns out to be the lower estimate, a plant with an 8 million or 10 million ingot tonne capacity might not break even, whereas a mini steelworks with a break even point of 3 million to 4 million ingot tonnes would be quite suitable. Secondly, large steelworks are operationally inflexible, since they demand virtually 100 % utilization, whereas the capital cost per tonne in a mini steelworks is only about a third of that of the integrated works, and its break-even point would probably be lower. Thirdly, the planning and construction period of a mini steelworks is easier to control. Mini plants are being located in the scrap-generating areas, that is, the southeast of England and the Midlands, and so there will be less scrap for an integrated plant and therefore an increased demand for a higher proportion of hot metal. Further, mini steelworks are flexible because direct reduction material in the form of sponge iron which is 93 % Fe, compared with the 67 % Fe of high grade iron ore, can be used. This means, especially if we depend on imports, a great saving on waste tonnage being transported. With one of these mini plants operating already and three more planned, producing altogether 2 million tonnes, the idea of an integrated plant is perhaps being overtaken by events.

He suggested that the prevalent view, that the cost curve continues to fall almost indefinitely, should be critically reappraised and policy decisions consequently reconsidered.

Sir Alastair Pilkington, F.R.S. (*Pilkington Brothers Ltd, St Helens, Lancashire*) thought that it was highly dangerous to take up an attitude towards size. On products which are fairly standard, economies of scale are usually the rule, but in other circumstances large size can mean inflexibility and sluggishness to change. Each situation demands close analysis. In a country like the United States of America where there is a large market for special glasses, it is an advantage to have large glass-making furnaces. In the United Kingdom, his firm has to have smaller units which they can drain and change very quickly.

Mr J. F. Safford (*National Economic Development Office, Millbank, London, S.W.*1) agreed with this and said that there were different economies of scale in different fields. The economies of scale to be achieved in research and development would not necessarily be those to be achieved in marketing or finance, and the approach within these fields themselves would differ from country to country. A balance has to be struck in respect of products and functions which seem appropriate to the particular field of operations in which one's company is engaged or wishes to become engaged.

Dr Feilden, F.R.S. said that one should be very cautious about transferring technology from one country to another without appropriate modifications. India, for instance, is labour-intensive and when steelworks were being constructed there, the use of bulldozers had been discarded in favour of women carrying baskets of soil. Technology has to take into account different social and industrial environments.

Referring to the earlier discussion on the cell system he said that one of the requirements of the human species is for a challenge in life, and a modern production line offers nothing but monotony. He wondered if the sociologists had any comments to make on the implications of this apparently fundamental need of mankind.

Professor M. Seaman (*University of Technology, Loughborough, Leicestershire*) drew attention to the work of the International Federation for Automatic Control which was examining the problem of the nature of the relation between control, whether adaptive or direct, as a technology, the structure of management, and the behaviour of the individuals in it. He felt that this was of great relevance to the speeches which had been made in the last two days. His point concerned the nature and the objectives of corporate bodies, which he defined as individual persons grouped together in a corporate activity in which they have power, money and resources to execute their purpose.

Professor Seaman showed a diagram which showed the conversion of raw material through the manufacturing processes into the desired specification. The transformation of resources into cash is the primary corporate objective of the manufacturing section of the industrial hierarchy. The diagram then goes on to define two specific qualities of control structure and hierarchy, the time series and the power series. The time series is different at each stage: in automatic processes the manufacturing stage is almost instantaneous; in other processes it might take days or months. These differences in time result in differences in the degree of control exercised over the manufacturing process by management.

Corporations not only need improved technology to introduce changes, but also the power to make those changes. A second diagram showed the corporate structure by which control is exercised by management. The problem is how to unify control; for instance, at present, financial control appears to lie with one set of people, while wealth production appears to lie with another set. Thus the power to determine investment in manufacturing industry does not lie with those whose specialist job it is to forecast and control. The structure of corporate bodies needs to be critically examined if corporate objectives are to be achieved.

I.F.A.C. has defined three such objectives. First, physical and service management, that is, the transformation of resources into cash; secondly, research and product development related to marketing; thirdly, human development, which modern society demands should be an objective of any economic system. The target of management should be a unified control procedure which combines from the data bank the financial control as well as the data processing control and quality control. We need to pay far more attention to corporate procedure, objectives and philosophy, and the Royal Society should spearhead the thrust to educate the oncoming generation of engineers and managers in these new concepts.

Mr D. Firth (*National Engineering Laboratory, East Kilbride, Glasgow*) said that the last two days had been dominated by the concept of optimization, that is, that all futures are based on optimization of present knowledge and techniques. Any innovation is very difficult to introduce because most large successful companies are managed by a body of men who are shrewd, realistic, middle-aged and bourgeois-orientated. Although perhaps dedicated to the function and purpose of the industry which might include support for innovation, innovation in fact represents a threat to their type of successful existence.

He divided scientists into two types. On the one hand, there are the innovators, rather wild-eyed, usually unmanageable, who will exploit natural law. On the other, the safe men who will

improve and optimize it until it can be improved no further: they have terrifying optimizational dreams which only stop when one of the innovators takes the whole thing a step forward. Companies must realize that ideas need finance and that they have to support research and development with money.

He pointed out the role of historical accident in the development of manufacture: religious persecution of, for example, Nonconformists had contributed to Britain's industrialization because they had been barred from traditional professions and businesses.

Finally, he said that he did not believe that Britain was yet a nation of producers; it is still a nation of shopkeepers. The industrial revolution of Britain was an aberration, the work perhaps of the fourth estate: presumably this is why engineering has such a working-class psyche in Britain compared with other countries.

Professor M. W. Thring thought that the greatest problem was that of limiting growth. It is not just a British problem but a world one. Quoting as an example the world's reserves of oil, he said that a saturation point was bound to be reached. Nothing can go on expanding at an exponential rate for ever; the curve has to turn over at some time and then we would simply run out of oil. What is needed is a plan to level off the growth rate.

He identified five major problems which face the world today:

(1) If we continue to have a large gap between the rich and poor countries, the consequent tension will almost certainly mean there will be a world war.

(2) The pollution problem is a global one and requires an integrated solution. There is no use legislating against pollution from the motor car if the fuel consumption of cars that meet the legislation goes up. Politicians must be taught the interaction of different factors.

(3) The rich countries of the world are consuming more than their share of the raw materials when the supply is already limited. This cannot continue indefinitely.

(4) Unemployment is a growing problem in most countries of the world. It will be increased by a slowing in the growth rate and by a relative decrease in consumption, for there is a limit to the amount that you can persuade people to buy. Unemployment in the rich countries of the world could be 30 % by 1990.

(5) Finally, there is the boredom and lack of challenge that Dr Feilden had already mentioned. Job satisfaction for the working man has almost disappeared and this has contributed to the malaise affecting the whole of society. He suggested that a radical solution was required. We must change the basic goal of society; success in life should not be measured by material possession but by self-fulfilment. We need an equilibrium economy, one in which production is not increasing and in which consumer goods last for much longer than at present. The number of people working in the production industries must decrease dramatically. Hours of work must be cut and more attention must be paid to leisure activities. He predicted an increase in service activities and a return to the land.

Dr C. A. J. Young, F.R.S., said that he agreed that it did not matter when the exponential growth curve was going to turn over, but he thought that in practical terms it was a waste of time talking about it because no one would listen. It is almost impossible to change things on a global scale. We can only hope to take a small step to try to model our own affairs so that our civilization is seen to provide a better quality of life which will set an example to the rest of the world.

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Professor N. Kurti, F.R.S. referred to a recent book by Fremont Felix which showed that in only one case, that of population, had an exponential growth rate been maintained over a period of centuries. In all other cases there had been a small tapering off, perhaps of 2% or 3%, which had had a profound effect. We could learn something from this study.

Professor J. M. Alexander (*Imperial College, London*) said that just because it was impractical to implement Professor Thring's suggestions overnight, that was no reason not to discuss them. All those involved in industrial research should ask themselves, 'What effect is this going to have on society?' It was right that these problems should be discussed in the Royal Society.

Dr Williamson said that much of what Professor Thring had said was undoubtedly true, but there was another side to the coin. We have to continue to make things and export things if we are to continue to eat, and this could not be ignored. Moreover, man's ingenuity might find adequate substitutes for raw materials.

Professor Muller further stressed the dichotomy, and said the conference was faced with two alternatives. Either it could paint a scenario of how the 1980s ought to look, or it could try to imagine how within the constraints of certain economic and sociological factors the 1980s would look.

Professor J. F. Coales, F.R.S. (*Department of Engineering, University of Cambridge*) disagreed with Professor Thring and thought that if we satisfied our own economy with raw materials and then turned to help the developing countries, the raw materials would not dry up.

Professor Alexander said that we should bear in mind the human values. It might be preferable to make industry labour-intensive and give people job satisfaction, than capital intensive, which would give people more leisure than they knew what to do with.

Mr J. A. Horne (*Timex, Dundee*) thought that while the 'wild' men had an important role to play in the development of civilization, they did the entrepreneur a singular disservice in being so totally confident that the rest of the world was stupid. He thought Dr Merchant's idea of 100% in-process gauging a useful concept. The weakness of statistical quality control was that it only picked out the faults when it was too late and it allowed too much to slip through the net.

He had been very impressed by the high degree to which technological processes could be perfected, and he gave as an example the process of spark eroding which enabled metallurgists to shape such refractory materials as tungsten carbide and titanium. If we can ensure that machines were incapable of doing things wrong, then we will have taken a very large step indeed in terms of the engineering industry.

But we will be deluding ourselves if we thought that the solution of formidable technical problems was the whole answer. We must remember the people, and we must be able to persuade them that the technological Utopia into which we are moving will not only provide an endless succession of fascinating problems for technologists to resolve, but will also improve the life of the working man.

Mr A. E. de Barr (*The Machine Tool Industry Research Association, Macclesfield, Cheshire*) thought that the conference was being a little glib in making various assumptions about what the rest of the population thinks and wants. We assume when it suits us that they like repetitive

work, or that they do not like repetitive work; that they like heavy tough jobs, or that they do not like heavy tough jobs. He questioned the validity of projections into the 1980s made by a small group of men at one end of the intelligence scale when 50 % of the population are of below average intelligence. It seems obvious to us that we should judge the kind of machine tools which ought to be used in India bearing in mind the scarcity of capital and the cheap labour there. In fact, India wants the same kind of machine tools as we have in the West. Their technology wants to grow by our standards. We are in danger of making judgements for the rest of the world on too little evidence.

Mr A. Arnold (*Hatfield Polytechnic*) said that he had done a great deal of work in developing countries, occasionally as a U.N. Adviser, and what they want is to be able to stand on their own feet. They look at the successful countries in the northern and western hemispheres and at what we have got, and that is what they want. It is unfair for us to start telling them what they should want.

In many developing countries human labour does replace bulldozers, but one of the aims of the U.N. agencies and one of the purposes of industrialization is to get rid of drudgery. He wanted a simple sort of formula for what we should be giving to the underdeveloped countries in the 1980s.

Dr Meleka said that consideration of the working environment in the factories and shops ought to be given high priority. Scientists should pay more attention to making machines less noisy and working conditions more comfortable.

Lord Halsbury, F.R.S., said that he disagreed with Professor Thring and Dr Young when they said that it did not matter when we ran out of fuel because it was going to happen sooner or later. If we can develop fusion power before running out of petroleum products then all will be well. Granted unlimited electrical power from hydrogen fusion, then we have great mountain ranges of limestone from which we can obtain carbon dioxide, and we can obtain hydrogen by electrolysis from sea water. Given carbon dioxide and hydrogen, the chemical industry can produce the light, transportable, safe fuel we call gasoline or petroleum. So the date could be critically important.

Secondly, if one could predict a growth industry, as it might have been possible to forecast the computer explosion which 13 years ago had undergone a 10-year induction period, then he suggested robotics might well be increasingly important over the next 13 years.

His main point concerned the social trends over the next decade. Production engineering techniques in heavy engineering change very much more slowly than they do in light engineering and there is a danger that the people working in these two industries would finally be working in completely different social circumstances. This could lead to social tension.

He foresaw a time when the 50 % of the population with an i.q. below 100 were not needed for practical purposes in the production of goods and services. How could these people be made to feel useful? This is easily done in societies which have an obsession: in ancient Egypt the pyramids were built, not so much for their practical use, but because the Pharoah and his people felt that it was important to build them. They made people feel useful. In his own youth, there had been more service professions, but these have now declined because they became too expensive. Similarly, as soon as girls working for pin money demand equality of pay, the job will be reorganized so as not to employ them. The problem is one of occupational therapy for the under-endowed.

Mrs G. M. Fazakerley (*Institute of Advanced Studies, Manchester Polytechnic*) thought that talk of getting rid of 50 % of the population was fruitless because the average i.q. would only go up and there would still be a lower 50 % that we did not need.

She referred to Mr Feilden's point about challenge and said that 10 % of the country still lived below the subsistence level. The conference had discussed underdeveloped countries, but there is a problem at home too of people struggling to make a decent wage and for self-respect in their jobs.

The profit motive no longer gives this feeling of self-validation. We are entering an era where companies are accepting that they have social obligations to the people they employ, perhaps creating activities that are intrinsically useful and allowing people to find validation in this. We have to be concerned with the quality of life and it is worth remembering that on 1 January 1973 we enter not only an economic community in Europe, but also a cultural one.

Mr D. F. H. Rushton (*Ingersoll Manufacturing, Daventry*) said that Britain had once been pre-eminent in the field of heavy engineering, but we had lost our lead, for example, in shipbuilding and railway engineering, and had allowed other countries to capitalize on our inventions. He warned that at the present rate we might not have a heavy engineering industry in the 1980s. While other European countries were installing modern gas turbine manufacturing capacity, Britain was retaining an out-dated steam turbine manufacturing capacity.

Progress in this field demands heavy capital investment and this is not forthcoming at the moment. We should not allow our heavy engineering history to disappear from the scene without at least some discussion.

Dr Merchant said that no conference of this nature could have been held in the U.S.A. without the words 'technology assessment' being heard. The impact of technology must be measured in four different spheres, political, social, economic and environmental. The law on car exhausts was introduced by the U.S. Congress for political reasons before the problem had been properly solved technologically. The result was that £100 was put on the price of cars, fuel consumption was increased, and exhaust emissions will be worse than they were before the law was passed. Congress has now established an Office of Technology Assessment and has taken assessment out of the hands of the technologists. He believed that such assessment was the responsibility of scientists and technologists and he urged those present at the conference to assume this responsibility to ensure that the technological developments of the future were acceptable in political, social, economic and environmental terms.

Mr A. P. Green (*Tube Investments Ltd, Hinxton, Saffron Walden, Essex*) said that he was involved in learning about the planning processes in large industrial corporations and one interaction he wanted to promote was that between technological thinking and business thinking. There are four approaches to planning in both these spheres; inactive, that is, do nothing and hope that everything will turn out for the best; reactive, that is, only act when a crisis looms; predicting and preparing for the future, with which this conference had largely concerned itself; and interactive, that is, trying to make your objectives happen.

The third approach is limited because if you are unable to predict, you may be thrown back on reacting. With interaction you recognize this limitation but set your objectives and adapt the system to achieve them. Managers in the third category rely heavily on technology because it will change things and they believe that things are easier to change than people, but the

interactive approach is neutral towards technology because its proponents believe it is only there to achieve certain discoverable purposes.

The central feature of the fourth category, the learning adapting system, is that one's purpose be defined. Modern education theory stresses that the child must not only learn, but should know why he is learning. Technologists must begin to think in terms of purpose, choice, free will and other such concepts which traditionally have been outside the sphere of the scientist. They must not allow someone else to determine their purposes for them so that inventions are turned into strange opposites of what they seemed at the start. Managers must decide how to match and dovetail the purposes of technology with the purposes of the firm.

Dr Williamson, concluding, said that there appeared to be wide differences in viewpoint. A central problem had been posed, how to resolve objectives which appear to give us some purpose in life as distinct from just converting ever-diminishing raw material into ever-vaster amounts of scrap. Perhaps it needed another J. M. Keynes to show us the way, to give techno-economics a new lease of life for the next 30 or 40 years. However ill-equipped technologists were to deal with it, he hoped that the conference had at least made some contribution to an understanding of issues which had great implications for the future of mankind.

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