RE-INVENTING THE FACTORY

Summary of a Seminar held at the Society's House on 22nd October 1985 with Sir Monty Finniston, PhD, FRS, FRSE, FEng, in the Chair

INTRODUCTION

This lunch-time Seminar was convened by the RSA-Cubitt Trust Panel, a sub-committee of the Committee for the Environment. An invited audience of 38, drawn from diverse fields, was brought together to discuss the question of factory design in a changing world especially in an era of burgeoning automation.

The Seminar was chaired by Sir Monty Finniston, who opened the discussion, which began with six introductory contributions briefly outlining the themes to be discussed.

NICHOLAS GRIMSHAW

Director, Nicholas Grimshaw & Partners, Architects, Planners and Industrial Designers

THE LEVEL of anticipatory planning within industry as a whole has been, and still is, very minimal. Leaving aside heavy industry, which has its own problems, mainly to do with controlling decline, the industrialist's brief to the architect (or more likely to the local 'design and build' contractor) is all too often to build him X square feet of space for a specific use – so it will not be available for other uses in the future – and it has to be ready within a very short space of time. The industrialist is not usually prepared to analyse the problems within his existing buildings and, indeed, often implies that it is presumptuous for an architect to suggest that he does so. However, on the few occasions when we have been involved in analysing buildings on an industrial site, the result has often been to advise that the very last thing that is needed is more space on the site. Very often the solution is a phased demolition job, resulting in the retention of a small amount of space together with the provision of new flexible space which can respond to future needs.

The word 'flexible' is, I think, the key word which relates to the future of industrial building, from the point of view of both briefing and design. In giving a brief to an architect, a client must be prepared to analyse the way his business has grown and changed and the way in which his facilities have been able to meet the needs placed on them. He must also be prepared to project his past analysis into the future to see what the implications on his building needs are.

Having carried out these analyses, the chances are that the modern-day industrialist will emerge with a brief for flexible space, and in this connection I would try to make a strong plea for the fact that flexibility does not cost additional money and has nothing to do with size – it is a question of design.

However, when he looks around him, can the industrialist find the flexible space he needs at an economic rent? I doubt it. On the whole, the many millions of square feet of speculative space which have been put up since the war, much of it in the last few years funded by pension funds, is of low quality. Although it might offer a minimal short life 'shell' for an expensive fit-out by a computer company (and we know that the cost of fitting out and equipment often exceeds the cost of building by three or four times), these types of buildings do not offer a long-term solution for manufacturing industry. They are usually large-volume, windowless boxes of poorly thought out accommodation from the energy point of view, and offering a very low standard of environment for the workpeople, both internally and externally.

Therefore, we must look for a higher quality product in the long term. I would suggest that the following brief would meet the needs of almost every middle-range industrial process.

First, the building must be an attractive and pleasant environment for the workpeople. There is very little difference in many industrial situations between the environment required for people sitting at desks working with bits of paper and that required by people sitting at desks joining small components together. The same environment should be provided, the same views outside, the same amenities, and the same working conditions. I would also stress that in to-day's and tomorrow's buildings, leisure facilities will have to be included. The line between work and leisure is becoming increasingly blurred to a point where much work will in future be done at home and many of the leisure activities which were normally done in 'spare time' can be done in the working environment.

Second, the building should be a wide span, double-height space, capable of being developed with mezzanine floors and with good floor loadings generally. Third, the cladding should be an intelligent skin capable of adaptability so that doors, windows and loading doors can be added or removed without major disruption.

Fourth, routes, spaces, and ducts for services should be 'designed' without the appropriate services necessarily being installed in the first instance. Fifth, the building must be energy-conscious so that process heat can be utilized and every possible innovation in energy conservation can be taken into account.

Finally, a word about new products and processes. There is much talk currently about the failure of British products – the fact that almost every item of equipment in people's kitchens and living rooms is not made in the UK, and the fact that so many of our well-trained and creative young designers end up in Germany or Italy designing products which are manufactured abroad and sell well in this country. If I had a say in the way the Cabinet spends its money, I would put £2,000 million, not into British industry, but into design innovation. We now have to go further back then simply modernizing industry and industrial buildings: we have to go back to the very roots of design.

However, if we do that, will we have the buildings or enclosures to put the newly-designed processes into? Or are they going to be fitted into archaic, leaking and ill-fitted old buildings? New processes need new buildings which are good for the workpeople and which are responsive to the changing needs of the process as it develops. We are not going to see a change in the feelings of the workforce towards products and processes unless something can be done about the working environment at the same time. If we do this we just might end up with some products and buildings of which we can be proud.

PAUL WILSON

Manager, Consulting Services, IBM United Kingdom Ltd

I come from an area of business which has a volatile market and a quick product cycle, which leads to quick changes in manufacturing the fast-moving technology requirements. We have to match those with a construction industry which is not quite as volatile as the market in which we are moving. We have to deal with that particular reponse rate and match our own strategic requirements. The solution may well be the pantechnicon flexible factory shed, as I have heard from the previous speaker, and perhaps it is. However, to some extent that is not universally true any longer. Unlike the old dark satanic mills where the structure was determined to a large extent not just by the cast iron of which they were constructed, but the size of the machinery which they housed, the factory now is much more than just the manufacturing process which it contains within it. Just as we have seen in offices a reduction in the amount of the clerical and the administrative population as a proportion of the total, so in manufacturing we have also seen a similar trend as regards the direct shop-floor worker, through increasing automation, with the proportion of indirect support increasing as a proportion of the total workforce.

That is not the only point. The factory staff quite rightly demand conditions at their work station, and their support facilities, to be at least as good as those of their colleagues in the office space alongside. I am talking in terms of cafeterias, rest areas and so on. Therefore, what we are really looking for in terms of factory space is a new form of flexibility. When we look at this matter we need to satisfy ourselves not just in terms of today's needs – technology, the manufacturing process and the people we house – but also in terms of tomorrow's needs, tomorrow's people and their expectations as regards the type of environment in which they wish to work. We

have to put that together in a solution which is geared to the design and construction process in which we have to live. Moreover, we have to achieve that in the timescales required in the computer industry and we also have to achieve a quality of design excellence which we would not wish to give up.

Our particular client basically has to develop – and this point was raised by Nicholas Grimshaw earlier – a manufacturing strategy for his sites and for his product line.

Therefore, when we look at our manufacturing needs we need to look strategically over a long period of time at the site development potential to provide for both the manufacturing needs and the support facilities of our manufacturing needs. We need to look at several things: the services infrastructure of the site; the extent to which chemicals or other services may or may not be required on this site; distribution, warehousing, traffic circulation and flows on and off the site. In short, we need a masterplan – a strategy for development on a particular site to meet an unspecified need for manufacturing over a period of time.

Therefore, within this framework we need also to develop a strategy in design terms which would perhaps allow a modular approach to construction, based on site servicing infrastructure and the masterplan parameters mentioned earlier. Basically, what we are talking about in this connection must be a design-ahead programme for our manufacturing facilities as a basis of being able to turn on the construction activity relatively quickly as and when the need arises, having achieved in advance of all that, all the necessary design and statutory approvals for that which we want to do.

So what are you asking the designer to design? In fact, you are not really designing for any particular need; you are designing for some future generic need. You are therefore asking for some service envelope within which a variety of activities can be housed in terms of shipping, receiving, manufacturing, assembly, offices and recreation facilities, as well as an overall servicing system into which our plant engineering people can plug their manufacturing lines, as they are needed. Primarily, we have to look at these manufacturing sheds not merely from the point of view of manufacturing: they are also buildings in which people have to work. Therefore, we have to provide within those factories conditions under which they can work profitably, effectively and happily.

The challenge to designers is to be able to design for us the best shed that they can, in a manner which provides a discipline within which development can take place over a period and provide facilities for good and effective employment. The challenge to the construction side of the industry is, basically, to build it as fast as they know how.

JOHN OSOLA

Chairman, NEDO Advanced Manufacturing Technology Group; Executive Secretary, The Fellowship of Engineering

The availability of inexpensive computers is having a profound effect on manufacturing technology and, in addition, on company organizations, management systems and hence on the way in which factories are going to be laid out in the future. There are eight principal new technologies which are involved, and all involve the application of computers: to inventory control, production control, machining, design and drafting, manufacture, assembly and test methods, flexible manufacturing systems and also to automated stores.

When the first computers appeared in manufacturing companies a decade or a decade and a half ago, they were usually large, main-frame units, and the principal requirement then was to provide a clean air-conditioned space to house those computers and their operators. Nowadays, cheap and efficient micro-computers and software make it possible to have free-standing or linked computers in all the principal departments of the company, frequently standing on the end of people's desks.

The successful implementation of these modern technologies in engineering companies was recently studied by the Advanced Manufacturing Systems Committee of NEDO and, with the help of the consultants, Ingersoll, we studied 40 examples in 25 engineering companies of the effects on those companies of their investment in advanced manufacturing technology. We found the following key results: material costs were reduced by 13 to 15 per cent; turnover of stock was more than doubled (or conversely the amount of stock and work in progress required for a given output was halved); tendering time was reduced by 80 to 90 per cent; delivery time

was down by 50 to 73 per cent; total production costs were down 14 to 27 per cent; operating profit was doubled or trebled; return on capital typically doubled. It was found that in a well-planned and well-managed modernization programme, the improved cashflow and profitability largely paid for the new investment without the need for substantial additional funds after the initial period of, say, two-and-a-half to three years.

Those are the tangible and visible benefits. However, there are a number of other more subtle consequences which, will, I suspect, increasingly affect the design of factories in the future. In this connection I should like to quote one or two examples. Computerization leads to a much closer integration of the activities of the sales office, the design office, the production control department, the buying department, the stores and the manufacturing operations. The old demarcations between these departments are disappearing and that is bound to be reflected in novel office lay-outs and arrangements. The much higher stock turnover and reduction of work in progress will lead to smaller stores of raw materials, and less workshop space occupied by a product in intermediate stages of manufacture. The drawing office will be much more intimately involved with the production control and manufacturing departments, and will probably have to be located close to those departments. The production operations themselves will involve the use of high performance computer-controlled machines, increasingly linked together by remotely controlled transporters. There will be less manual movement of materials and more conveyors and robots will be used. These will need smoother floors, cleaner workshops, the automatic removal of waste materials and a substantial reduction of noise levels. That would be required anyway, since the offices are going to be placed much closer to the shopfloor operations. Less space will need to be allocated to finished goods stores.

On the other hand, additional space may be required for computerized testing of components and assemblies to meet today's very high and consistent quality standards. Maintenance departments may need to be larger and fitted out with sophisticated diagnostic equipment and repair and adjustment facilities. They will need to be clean and perhaps air-conditioned

Finally – and this is probably the most important factor – we come to the impact of advanced technology on all the people who work in the factories. Skilled workers are nowadays trained to programme their own computers, and many have technical qualifications of a similar standard to those of the people who work in the drawing offices. Many companies are introducing staff employment conditions for everyone. Trade unions are taking an enlightened attitude to these changes and, indeed, are taking an active part in retraining their members and upgrading their skills to meet the needs of the new technologies. More space and better facilities will be required as far ahead as we can see for company inhouse training facilities for all levels of employees from the management downwards. It will be a continuous process in all enlightened companies.

We are seeing the disappearance of old-fashioned segregation by means of separate staff and works canteens, washing and changing facilities, car parks, and other divisive anachronisms of that type. There will also be an impact on traditional shift-working patterns, as many of the new machines can almost look after themselves. All these 'people' factors will undoubtedly have an impact on imaginatively designed factories of the future.

KEN CURE

Executive Councillor,
Amalgamated Union of Engineering Workers

Manufacturing industry is a dangerous occupation for everyone involved. Compare the figures for fatalities and injuries at work: those suffered by members of the Fire Brigade Union were one-seventh of those in a district of the same size of the engineering union. Therefore, one of the matters which we have to look at for the factory of the future is a safe working environment.

I have served on the same committee as John Osola and we have shared a number of experiences in this connection. One thing I have noticed is that while it is fairly common to landscape offices, I have yet to find a landscaped factory. Landscaping must be taken into account when designing the factory of the future.

I can remember that when I first started jig-boring, I went into a jig-boring pen and that was the first time that I had experienced working in air-conditioning. It was not because they

thought I needed air-conditioning; but because they thought that the machine needed it. It is a temptation, particularly when you are dealing with bricks and mortar, steel, fabricated sheets and floors of various ceramic compositions, to leave *people* as an afterthought.

Part of the history of industrial relations is the Fawley Agreement. One of the points that then arose was that people need breaks when examining monitoring equipment. It was found that watching what are now called VDUs for a great length of time led to a tendency to suffer from self-hypnotism. Whatever you can do to ensure that this self-hypnotism is dissipated will, in my view, be a contribution to the future mental health of the population of the United Kingdom.

I have been involved very recently in some discussions on computer-based training, because of my involvement in the SATUP in the Open University. One thing I have learnt is that there is an increasing requirement, because of the changes in technology and the pace of those changes, to be able – not too far away from the point of production – to engage in some form of retraining.

One of the earlier speakers talked about recreation. Let me re-pronounce it in the way in which I believe it was originally intended, '*re*-creation', because that is a very important aspect of the way in which you look at people's involvement in industry.

N. C. R. BLACKMORE

European Marketing and Agent Administration Manager, Unimation [Europe] Ltd

The site about which I should like to talk today is part of Westinghouse, which is Unimation's parent company. I visited it two months ago, and the story which unfolded when I visited it was unusual. The need for it was established eighteen months before the planning for it began. The planning started eighteen months before they decided where they were going to put it, and they only decided where they were going to put it when they decided which university they were going to tap for recruitment. As a result, although they buy nothing there, and they ship nothing to the customer from it, everything which is used in the factory in College Station in Texas is bought 1,500 miles away in Baltimore. It is flown in daily. The finished product, which is printed circuit boards, is flown out nightly. The entire workforce, with the exception of about ten supervisors or managers who are old Westinghouse hands, has been recruited from the next door Texas A and M University, with its student population of 35,000. That is the reason why it is located there.

The communications are very bad. The temperature is unacceptable, except in air-conditioned motor cars, motel rooms or the totally air-conditioned factory. It is 180,000 square feet. It has no fixed walls internally – the whole place is offices, meeting rooms, factory and computer rooms all on the one site. There is one cafeteria, one car park and 420 souls. They are just about to double its size, because it has worked. What is frightening is that there is absolutely no paperwork. Everybody signs in daily to the computer, is allotted his work by the computer, has his work delivered to him by the computer and has his work taken away from him by the computer. When you go to the cafeteria, the computer deducts the cost of your meal from your monthly pay cheque. It also ensures that you park your car correctly and that you visit the built-in sports complex and gym regularly, and that you have your medicals regularly. It all sounds Utopian and I am awfully glad that I only visit it once a year!

Utopia, as somebody discovered long before I did, is delightful, but boring. Being a fallible creature with weaknesses, I found that regimen not to my taste. However, it is better than a shed and it is a great deal safer. In fairness, it is highly automated; it is highly robotized; they can give you the individual part history of every chip in the building by going to a VDU and tapping it in. The entire place is computer-controlled, and the computer is in Baltimore. There is a standby one in Texas. They speak regularly to each other every 28 milliseconds. If one of them misses the call, then they alert the second computer which is in Dallas, which comes to their rescue quickly. It also tells speakers how long they have got, and I am watching!

One of the fascinating aspects is that they are in a position more accurately than in most factories that I have ever visited to measure productivity, quality, work in progress, the inventory, the age of the inventory and so on. You all know the story about the little black book with only two numbers that really mattered when

they were being produced by the computer load. They produce numbers faster than they talk back to Baltimore. Every 28 milliseconds something comes spinning off that machine. However, there are savings in real costs, in manufacturing costs, in lead times, in labour, and in parts, but the biggest saving of all in hard pounds and pence has been in stores – the amount of finished product and of raw material which was kept in Baltimore. They have been able to do that by virtue of the fact that everybody who does anything in the factory 'pens it in' – there is no paperwork. When they make a batch of products they write that that product went through that operator, on that day, at that time, using that equipment, and so on. Therefore, they build up a total history of every component part, assembly and personal record.

They also measure things, like re-works, which are very difficult to measure in conventional factories. When somebody does something and realizes himself that he has made a mistake, he re-works it. The reduction in that type of effort has been quite dramatic.

JOHN WORTHINGTON

Partner, Duffey Eley Giffone Worthington, Architects and Space Planners

In preparing a brief it is important to understand the changing nature of industry. I am not sure you can begin to design effective 'building shells', and the interior working environment unless you do.

I should like to distinguish between the production of components, such as the microchip, which is a high-tech product requiring a high-tech process, in a high-tech building, and the production of high-tech products such as a micro computer, which requires a low-tech assembly process. The microchip may be used for many different products which are short run, and are tailored through the application of knowledge. It is the people's business to apply those components and to assemble them into lots of different products.

What does that mean in terms of design and briefing? We can distinguish between the shells of buildings and the fitting out within that adapts them to a particular process. The basic building is one into which we might fit many different processes. If it involves the production of components there may be a tight fit between the building and the process inside. However, if it concerns the assembly of components – which is in the majority of cases what we are talking about – into lots of different products, it may be rather a loose fit. It could be a rather nice old nineteenth-century mill building which we are moving into – I disagreed with Nicholas Grimshaw when he said that there should be new buildings for new processes. I suggest that sometimes it should be old buildings for new products. Digital has a very successful old mill at Maynard near Boston.

Therefore, we could be using all sorts of different shells. What is important in terms of the briefing process is the 'scenery' which goes inside 'the shell', to adjust to ever-changing activities and, even more important, the settings which will be provided over time by the users reorganizing the scenery: what I call 'design in use'. In other words, we, the architects, no longer design the final end product – we transfer our concepts across to the people who will be using and managing the building, and continuing to design.

That brings us to the design decisions about how we choose a shell. Industrial users sometimes build themselves a new building and sometimes use existing spaces. The issue is about adjusting the organization to the shell and setting up the process to allow for continuous change. Today we are faced with shorter product lifecycles and a faster rate of change in organizations as they mature. A typical 10-15 lifecycle in the electronics sector might be an infant firm which has marketing, administration, pilot product lines and research all in the same building, moving to maturity where they have a separate building for research, manufacture, administration and customer support.

Finally, what are the new skills we are looking for? I envisage a new type of designer – we term them 'facility managers'. They are the building animators; the people who can identify opportunities through time. They can educate, can help to transfer those ideas to other people to show them how to use the building in the best way and make the match between organizational and building design. They can both design and manage the total resources. The most interesting companies which I have seen are the ones which have merged the planning of personnel, premises and automation – whether it is office or industrial automation – all under the same function. It is a new rôle, which as yet does not exist. It could be filled by architects, accountants or anyone who can merge both planning and implementation, and understand continuing design of buildings.

DISCUSSION

THE CHAIRMAN: We shall now move to the general discussion beginning with the questions which some of you have written down and which have been given to me. The first is, 'Where is the sensible place to put the computer-integrated factory of the future? Is it away from population centres? Or is it close to the appropriate transportation interchange? Or is it underground?'

MR OSOLA: I think that the key point has already been touched on. People are crucially important. A great deal of the development in the South-West and the Bristol area was based entirely on the availability of people with the right skills. Assuming that the ground is available there, nearly all other factors are secondary.

THE CHAIRMAN: We have 44 universities and 30 polytechnics and so we do not suffer from a shortage of skills, if we want them. What does it mean for this country?

MR BLACKMORE: Our company felt that the most important point was to have a source of the kind of people who they knew they wanted. There was also a feeling within the planning team that they wanted to be in an area which was not industrialized so that people did not come with a rather less flexible frame of mind. People are constantly moved around, because some of the jobs in circuit board manufacture are extremely boring and repetitive.

THE CHAIRMAN: We have not yet addressed the question of whether we need to have a transportation system. The computer has been invented and people can speak to each other through the computer.

MR ANDREW DERBYSHIRE (Chairman, Robert Matthew, Johnson Marshall, London Ltd): I do not have the answer to the question (which was raised by me) and I am not taking sides. The technology is available to produce coal-fired electricity entirely automatically and it is conceivable that coal could be produced automatically. The obstacle lies in industrial ethos. It is the tradition in the coal mining industry to produce as much coal as possible, but it is a tradition in the electrical power industry to produce electricity as cheaply as possible. The unions, the workforce and the management concerned are running their industries against two diametrically opposed objectives. If we are to achieve greater flexibility in the location of manufacturing industry in relation to transportation, which I think is a key issue in terms of future regional planning in this country, I want to know how we can reconcile these different kinds of ethic in different industries. Since we invented industrialization we have inherited a more treacly, difficult problem than any other country in the world. I think that we ought to try and face it. I was hoping that this meeting might attack that problem.

PROFESSOR DENIS PYM (London Business School): Everyone who has spoken so far has spoken on behalf of his employment. In this country most people centre their lives around where they live, their homes and communities, and want to do so more. As we are addressing the future, I see no sense in defending my employment.

Owners, architects and builders are being faced with a choice in terms of 'places for creating wealth'. They will either be building factories for machines or developing space for people. In this respect, they have to find ways of making it possible for people to reunite their social and economic lives – as many who are self-employed do already. You have to decide, for your own businesses, which route interests you. Is it all out for high tech and getting people *out* as fast as possible, or building economic units in which technology has a rôle subservient to people and their needs? Such units would emerge close to and around where people live so that they could be an integral part of their lives. I think this situation follows from the realization that there is no future for universal employment, and the sooner we face it the better.

THE CHAIRMAN: There are solutions for people who are not being employed in the conventional category of work. For example, there is nothing marvellous about the five-day week. If you can produce things in three days, you can leave the other four days for whatever is necessary. People are retiring earlier and they may be compelled to do so. What do you build for them? Do you just leave them in their homes?

PROFESSOR PYM: No, employment represents for most people a divorce between economic and social life. People, many people, want to pursue economic activities around where they live. It seems to me that owners have not yet got around to recognizing that most people in this country take their private worlds more seriously than their public rôles. We devote more energy to the private and less to the public and it's time we understood our so-called economic decline in these terms, as an opportunity to make more effective use of our energies.

MR WORTHINGTON: I entirely agree with you that the problem concerns a re-definition of the terminology; the concept of the factory has to be redefined. Certainly in terms of planning law there are some major issues about what is an industrial use, and

what is an office use. We also have some extremely interesting fringe activities which are probably closer to what the new work environment is about. The concept of the 'neighbourhood work centre', where work can be undertaken close to home, and linked to the main place of work by computer, is emerging in Sweden, and for Rank Xerox networkers in the UK. There is also the 'innovation centre', the place which is halfway between the place of education and the place of work. A new set of institutions with new names is appearing.

MR DAVID FIRNBERG (Managing Director, Eosys Ltd): All the discussion so far has presumed that the factory is a place; a building with a defined entity of four walls. The factory is not a place; it is a system. It consists of components which link in the one case market demand and in the other the profitable satisfaction of that demand. Within that system we need designers who can create coherence, and not architects who are obsessed with the particular physical structure of a place.

The various components of this factory system will be variously located, and regularly re-located. I question Professor Pym about whether the issue is space where people have to live to be near their work, or space where people want to live. Telecommunication links remove many of the geographical constraints between the various factory components. We heard someone talk about the design facility needing to be next to the manufacturing facility. The Consumer Products Division of General Electric in the United States has its design facility in Singapore. They are linked by a high-capacity satellite. My question is this: who will design these coherent systems and the various components in the systems?

THE CHAIRMAN: On the basis of that statement, the place does not seem to be important for service industries. Design is a service. There is no physical product except paper. Therefore, as regards services, it is possible not to have a factory; you can stay in your home and operate. However, what about manufacturing, when you are producing a physical reality, a product?

MR FIRNBERG: The distinction has already been made between the component and the final assembly. It could well be that you will variously locate the final assembly plants near various markets, rather than locating them centrally and then distributing. The components are the raw materials. The micro electronic chip is raw material. You manufacture the chip wherever it is most cost-effective to manufacture it, and you deliver it to your assembly plants.

PROFESSOR FRANK HEIGHT (Professor of Industrial Design, Royal College of Art): My interest is in engineering and industrial design. At present an important aspect of design which is preoccupying me is the need for integration of engineering and design specializations. For example, the data base on a computer can become a common data base for everyone concerned with the origination and development of a design – engineers, industrial designers, ergonomonists, estimators and others.

Apart from this, however, is the real danger caused by the decline within British industry of design groups and the growth in their place of design consultancies. One reason for this is the lack of support and management of design within industry and a general environment which is inimical to creativity. On the other hand, the management and environment in the consultancies are arranged to encourage imagination and creativity.

The design officers in industry need to be regenerated. But design is not the sort of activity that will fit in with the planned and precise factory systems talked about today. We must create in our new factories new creative centres where unusual things can happen.

MR DERBYSHIRE: It has proved difficult, in my experience, for building design teams to get close to the user clients both in management and the workforce. In some cases we have been commissioned to design a building whose purpose is regarded as supernumerary, rather superficial and irrelevant to the main function of manufacture by the appointed project manager. Such a manager, in order to maintain a power position, may wish to keep us from talking to the users of the product we are designing. I suspect that the same may have happened in industrial and product design, in manufacturing organizations. Managers seem suspicious of designers. Until we can establish better communication and more mutual trust we shall be stuck, as we are at the moment, both in product design and the design of production facilities.

THE CHAIRMAN: The question which I have received from Mr Lyall is this: 'There has been a great deal of talk about total automation and middle-class management, but where do the people come in? What do you do about and for them?' The discussion seems to be polarizing about the proposition: I know how to build a factory for machines, but I am not sure how you build a factory for people, if you have to have a factory – which of course is being denied.

MR CURE: Before you talk about what people want, you have to ask them what they want. While you may think that you know what they need, it may not necessarily be what they want. In my experience, my members talk about work which gives them a value in society. There is nothing more disturbing to the human psyche than to talk to unemployed people who

feel, as a result, worthless. We have not reached a position in our society where we have been able to change people's work ethic concept of the value of life, at least not on any large scale.

THE CHAIRMAN: Mr Small makes a statement: 'The primary purpose of factories is wealth-creation.' If you have to have a factory for wealth-creation it has to house people and machines. Are you saying that you have to meet both parties nowadays and the suggestion which has been raised about having the social and economic life of the community settled rather than the factory settled is not how you would do things?

MR BRIAN W. SMALL (Managing Director, Ingersoll Engineers Inc): This is correct. I am worried about people too. However, in my view, the first matter which the people are concerned about is not having a lower standard of living next century. Whether or not the manufacturing industry is going to be the source of employment, one thing is for sure: the manufacturing industry had better be the source of wealth, because manufacture is the vital source. If we are to do that, then the purpose of the factory is to keep the rain out and to do whatever it can to help the people who are inside to produce products at a good price, with good delivery and quality. Nobody has discussed that subject yet today. I think that it is one of the problems in this country.

DR ERNEST APPLETON (Lecturer, University Engineering Department, Cambridge): I think we should take a broader look at what we regard as manufacture. The traditional areas of processing of raw materials will move to the Third World and to hope to compete with them by clinging on to our traditional industries will not be a successful route. The resources we should be using to create wealth are an indigenous understanding of new technology and a relatively educated population.

Another point I would emphasize is that we should not concentrate so much on fixed-location factories. Some of us prefer a choice of workplace and I think flexibility is the key word here.

MR OSOLA: We appear to have a particular cultural problem in manufacturing industry in Britain, and I think that it is peculiar to Britain; namely that for some reason we regard design as a different activity from making. This is a concept which crept into Britain some time towards the end of the last century when we were already starting to go down the other side of the peak of success. George Stephenson in 1847, in his presidential address to the Institution of Mechanical Engineers, issued a specific warning to British industrialists about this. He said that he had just come back from the Continent and reported that our Continental competitors were starting to make things by methods superior to those used in Britain, and that if we were not careful we would start to lose some of our world business. At that time we had 70 per cent of the world's manufacturing business. He was concerned in 1847 and it worries me very much when I hear people still talking about designing and making as if they were separate activities. They are two aspects of the *same* activity. I believe that the factories of the future, and the organization of manufacturing companies, must recognize that people who design and people who make are going to be of equal intellectual calibre – they are going to have similar kinds of education. The distinction between the person who designs and another one who makes must disappear. That concept must go right through to the professional level.

It is extraordinary that in manufacturing in this country we recognize two kinds of professional engineer: on the one hand, mechanical and electrical engineers who are thought to be suitable to carry out design and, on the other hand, production engineers who are responsible for making things. We must get rid of this distinction. I believe that the designs of our future factories, and the organizations within them, must take this very fundamental point into account, and quickly.

MR WORTHINGTON: If we are really going for 'people environments' which will foster the application of knowledge and ideas what interests me is this: the merging of organizational design and building design, and then the setting up of processes to allow them to develop through time. That is probably where Britain's future wealth-creation will be founded.

MR SMALL: As someone who actually earns his living from computer-aided design, FMS, CIM and so on, I can tell you that for the next two or three decades factories will be people-driven, they will not be technology-driven. If we listen too hard to the technologists and believe them, we shall have exaggerated ideas about the level of change over the next two decades. We will still have factories and products being made in ways which are not a quantum change from what we are making today and which we may well be importing already.

MR KEN CURE: So far we have not reached a position which is any different from that which Mr Small described – it is a people-driven exercise and will be so for two or three generations to come. But education will have to be woven in so that the work ethic itself changes somewhat – I am not necessarily saying that it will have to change drastically, but it will have to be changed in some way so that we reach the stage where people feel completely liberated by the new technology.

THE CHAIRMAN: The implication of that is quite clear: we here should not be discussing building the factories of the future; we should be talking about building leisure centres or creating post-retirement centres for people, which might necessitate a different kind of building with different kinds of facilities.

SIR ANTHONY BURNEY (Member, RSA-Cubitt Trust Panel): Surely you will have both. To come back to the point about wealth creation, we shall not have leisure that we can enjoy unless there is some wealth which can be used to pay for that leisure.

We must start with wealth-creation. I entirely agree with Mr Small in that respect. The objective must be wealth-creation and in pursuing this objective we will get all sorts of other benefits – we will have an efficient factory in the right place, we will have people concerned with the market for its products; we will have people concerned with its manufacturing facilities and the skill of the workforce and we will have people concerned with the design of the factory. Professor Pym says that it is people who will build the factory and I agree with him. However, it will be all sorts of people; it will not be just one person; it will not be an architect; it will not be a managing director. It will surely involve a team of people who will discuss the various problems involved in building and operating the factory and who will jointly arrive at a solution which, hopefully, will be an optimum solution, but which will inevitably be to some extent a compromise. The computer will be one of the tools which they will use to enable them to take better decisions.

THE CHAIRMAN: Let us go back 100 years – three generations, which is not a huge timescale. In 1885 there were no motor cars; the motor car was only designed in that year, nobody owned one. There were no aeroplanes; the aeroplane arrived in 1906. There was no processed food; that arrived in 1920. There were no zip-fasteners, because zip-fasteners were invented in 1897. There was no nuclear energy, because that was introduced in the 1940s. There was no transistor because that was introduced in the early 1930s. There was no TV, because that was invented in the late 1930s. I spoke to some children and I said that they ought to have an examination paper asking them to list 100 things which their grandfathers did not enjoy. To talk as if in 1985 this process has come to an end is absolutely absurd. As a result of all the innovations which have taken place in the past 100 years, we have modified the way in which we live, how we operate, how we work and how we enjoy our leisure. We have not given attention to the fact that the future will hold equally remarkable changes. Robotics will change factories; genetic engineering will affect the health and care industries; the optical fibre will change communications and the fifth generation computer will change the way we do things. I do not think that we have come to terms with how we are going to accommodate these changes by changes in the infrastructure of our society. We have not dealt with that, and that is what I was hoping to find out today.

MR SMALL: To answer a question which was raised just now; to visualize factories working in the middle of the night with no lights and no people is to have a wrong idea of the technology of the future. If we start to visualize factories which are moving with much shorter lead times, with people actually being able to correct mistakes more quickly and being able to produce better quality, we shall have a real picture of what the technology is going to do. It will not involve the unmanned factory with everybody out in leisure centres and nobody in the factories themselves. It just will not happen.

MR JOHN COLLINS (President, British Robot Association and T I Domestic Appliances): The problem, as I see it, is the dichotomy regarding the architect and client. When the architect designs for the machine alone, he gets it right. Where he comes unstuck is when he designs for people and machines together. He comes unstuck because of the perceived value of the wealth-creator, his customer, for the people in the system. The people in the system are not the paying customers, they are a necessary additive to the machines and so they are dealt with as such. To raise them to the level of the Harrods' shopfloor worker, you have to change the nature of the view which the wealth-creator has of the piece of equipment – which is the person – in the scheme of things.

I would ask the architect to address the wealth-creator in that sense to establish whether in fact between them they cannot come to some conclusion as to what the person in the middle is. Fortunately, that dichotomy does not have much time left, because we shall create machines which will produce the things which we want without people being directly involved.

MR GRIMSHAW: I am flattered to think that we are the people who might decide about this type of matter. The point I was trying to make is that we create the frameworks for people to do things in, but we do not decide what they do in them.

MR COLLINS: On the contrary, you decide the price of them, and when you get beyond corrugated iron, the price is very high.

MR GRIMSHAW: The price is pretty immaterial really. I should like to raise something which I think is very important and that is the question of size. I know of one company whose policy it is never to have a building or plant bigger than for 300 people. A building or framework which will accommodate 300 people, say, at 200 or 300 square feet per person,

covers about 80,000 square feet – a space equivalent to that taken up by, say, a row of 40 houses in a town, back-to-back; that is not a lot of space.

Where buildings of such size are put does not really matter, as they can be easily accommodated within any town, city or village. They could be smaller and could even occupy the 40 houses which you do not want to pull down. What we are talking about are not highly-specialized, expensive plants but simple, flexible frameworks which can be injected anywhere.

MR D. G. DAVIES (Executive Director, The HUSAT Research Centre): I should like to pick up the point made earlier that we are not very good at designing systems where we have people and machines. The Research Centre of which I am a part has been looking at this issue for many years and experience shows that we in the UK are not very good at putting together people and machinery.

I venture to suggest that the design processes used to develop factories are at fault because they do not take into account that we have a socio-technical system. The focus of attention is on the technical and not on the people who will have to interact with that system.

The essential problems relate to the fact that the human-system interaction is less than satisfactory; either some facet of the needs of human beings or certain of their characteristics has not been taken into account. The HUSAT Centre believes there is a need to change the way in which we design computer systems. We need to involve in the design process those people who have a perception of what is required, which can often be unique and vital to an effective design. We have practised that approach and found it very successful. By involving the people who have to use the machines, it has also made the introduction and acceptance of the latter much easier.

Further, the initial design activities involving users should be part of an ongoing process; the design of the factory is really a part of the total business operation. We cannot conceive of the design of a factory as a watertight entity in and of itself; it has to be integrated and related to all the activities of the business, and it must have a wide variety of objectives. It is a balancing act between different requirements, both technical and human.

I should like to mention one example of what I am talking about: a British company with which we worked which had a subsidiary in Scandinavia where attitudes towards people, their place and needs in society are very different. They involved users, the shopfloor workforce, in the design process of new factories, machines and systems. The approach proved highly successful and many innovative ideas came from the workpeople, who readily accepted the new process and new procedures.

When the same company tried to apply this approach in its UK operation, it met severe problems, many due to the different social/organizational context. Members of the workforce involved in the teams discussing design felt inhibited by the presence in those teams of their senior managers and did not make the type of contributions about which we have spoken. Changing a design process enables everyone to perform in the required and particular rôles needed. The facilitating activity which helps people into those new rôles is essential for successful changes in design processes.

MR F. E. NICKLIN (Architect Partner, Ryder Nicklin Partnership Ltd): Following on directly from that and also taking up Andrew Derbyshire's point about the best design in industrial building coming from direct 50:50 partnership between users and designers, I should like to point out that in 1984 there was about £2.3 billion worth of private industrial building completed in the UK, of which one-fifth was certified by architects. I say 'certified' advisedly because I avoid the use of the words 'designed by architects'. The greater part of that will have been routine, spec, junk, produced to a very basic and extremely depressing formula.

The necessity is to get users, producers and designers into close and fruitful contact. This simply does not happen in this country in the way it does elsewhere. The user can only define his needs in terms of what he has already experienced, whereas the designer can redefine the user's needs in terms of what is possible and what can be done. Our problem at present, quite apart from the question about where the future lies, is that the mechanisms do not exist for the contact.

A very successful factory which we recently completed provides an illustration of what I mean. The organization concerned had several inquiries from their opposite numbers in other factories asking who their contractor was. Fortunately these inquiries were referred to us and we explained that the contractor is in fact appointed quite a long way down the line. The point is that very few industrialists seem to understand the rôle of the designer and what he can do to improve efficiency, quality and so on. Industrialists need to be educated.

THE CHAIRMAN: Are you saying then that there is no physical obstacle to meeting the demands of whoever is concerned with the design of a factory of the future? You can accommodate any request: you can design it?

MR NICKLIN: Yes, of course.

SIR PHILIP DOWSON (Member, RSA-Cubitt Trust Panel; Partner, Arup Associates): Andrew Derbyshire will know that I would be a little more

optimistic than some of the speakers. I am reminded of an industrial and office building which involved the Tavistock Institute before ever we, as designers, were appointed. A real effort was made to determine the concerns of the community, which was coming from many different places to join in one new building, and to try to itemize and understand the type of social anxieties.

There is a responsible view from good management about the rôle that they themselves have to play in formulating a brief in concert with many other disciplines, of which architecture is just one. Again it depends upon sensitivity and understanding of the whole problem about which there is nothing special or new. Both the problems and the human beings have always been very complicated. In conjunction there is inevitably the problem with which we, as designers, have to come to terms. When we talk about trying to impose technically-based and machine-based solutions on human communities, I am not surprised that we get disasters. I think that in this country our factory design in some fields has led the way.

MISS EVA JIRICNA (Architect): I should like to comment on the last point. The problem concerns not only the people working in the factories but also the people who are designing for the client. Some comment was made about architects who 'did not get it right'. Being an architect, I should like to point out that it is also a question of how the architect is briefed by the client. If the client does not understand the brief, there is no way that the architect can interpret it.

THE CHAIRMAN: What has been said here is that we have not done enough to interpret the needs of a client and then to incorporate them, if at all possible, within the design. The architect has been less extrovert then he should be in trying to find out what happens.

MR DERBYSHIRE: He has been isolated, but not from choice.

MR GRIMSHAW: It is a question of a demand to be involved in the process, but with the client and the workpeople too. I agree with Eva Jiricna; the client's side, if you like, is as guilty as the architect's – and many of them are guilty – in not throwing their hat into the ring.

THE CHAIRMAN: To what extent does your professional institution carry responsibility for this? After all, they are supposed to uphold the quality of the profession.

MR GRIMSHAW: They tend to be crawling towards clients and the problem is that they do not, on the whole, demand proper briefs from the clients.

DR SUTHERLAND LYALL (Consultant, *Building Magazine*): I have a particular interest in industrial building, because it is perhaps the most visually interesting area of architecture of the last decade; maybe because the planners do not take much notice of it.

All the criticisms made today about architects not doing the right thing, are pie in the sky. All this stuff about human interaction, machinery, processes and so on, does not have any reality in real life when people commission buildings. The Industrial Building Bureau did a study which showed that when most people build a new factory or industrial building they do not even bother to do the accountancy sums. Their decision to modernize is reached because of the need to keep up with competitors, the opposition. It is nothing to do with making life better for the workers or buying new machinery.

MR ALAN OSBORNE (Member, RSA-Cubitt Trust Panel; Chief Executive, Tarmac Construction Ltd): Whether we are an architect selling our wares to our customer or a contractor selling our wares to our customer, we need to persuade him that what he is going to buy from us is as flexible as his degree of uncertainty about tomorrow. The industrialists do not know what changes will take place, so how can we, as builders, contractors and architects, tell them what they want? Our job is to give them a building with the building scope to change as the manufacturing process changes.

The other point emerging from today's discussion is that there is a group of people missing, called systems engineers – systems analysers (human). We know about efficiency machines and we know about the people in their social clubs, but we do not know enough about human systems analysis and relationships. How do we design workplaces to make the people most effective? Sometimes the engineers, the architects or the designers need to talk to the shopfloor; sometimes not, but it is part of human systems analysis. The architect is in a difficult position. He asks questions about process relationships, but does he ask enough questions about people and their workplace relationships and needs?

DR LYALL: Is he allowed, in most cases, to ask those questions?

MR OSBORNE: I do not think that the architects sitting around this table would be coy in asking. Having asked, they can then suggest the reason why it is important.

DR LYALL: I do not think that that is allowed.

MR OSBORNE: I think that it is. We often tell clients that they cannot afford something. Our job as architects is to press them to truly find out what they need and can afford so that we meet process and workplace needs.

DR LYALL: I think that that is describing an ideal world.

MR OSBORNE: That is the way we all get jobs.

MR NICKLIN: All the designer needs is direct contact with the user so that he can ask the relevant questions which, it is hoped, will lead to a creative result. The problem is getting the designer, whether he is an artchitect or an engineer, or both, into direct contact with the users. The way in which industrial building gets built at present simply does not allow that to happen except in a very small proportion of cases.

MR DERBYSHIRE: One thing we need to do is to identify cases where this has happened and it has succeeded. If we can demonstrate successful cases, then maybe they will encourage the others to have a go themselves.

THE CHAIRMAN: I now have the impossible task of trying to summarize what has been said. Winston Churchill once said, 'It is always wise to look ahead, but difficult to look further than you can see'. I do not think that we have been very far today; we have certainly not seen to the end of the twentieth century, because we have been concerned with trying to get the philosophy right about what we are trying to see and who it is we are trying to please in the design of our factories and our work-spaces.

What has come out quite clearly, however, is that in designing factories for machines we do very well. But it is when it comes to accommodating people within that environment that the difficulties arise. The general assumption has been – and people have spoken about this more than anything else – that the modern factory does not cater for people in the same way as it caters for machines. I remember that many years ago I commented that it was interesting how, when directors ordered a new machine costing, say, £100,000 they would go down to the factory to look at it goggle-eyed to see that it was well looked after; but when they recuited a new man to the organization, who had also cost £100,000 to train, they never even bothered to introduce themselves, and probably did not know that he existed. I guess that that shows the attitude of our modern industry. I do not think that it is peculiar to this country; it happens generally.

The first point which emerged was that the factory of the future would employ fewer people. The number of people employed in manufacturing industry has dropped in the last 25 years from 8.5 million to something under 4 million; it is the biggest source of our unemployment at present. It is quite clear that those people will play a lesser part in the sense of numbers, but they will play a more important part in the sense of the skills which they apply to the job. The factories will have to make them feel ergonomically and psychologically satisfied. They must look upon the workplace not as a place of combat, but as a place in which they can, if not relax, at least not be under tension. The designer has to accommodate that. It came out that in very few cases was the intending operative asked what he would like to see done. In a factory of 300 it is very difficult to satisfy everyone, but at least the effort should be made to try and find out under what conditions they would work most effectively – I do not say efficiently, but effectively. The designer has a responsibility for gathering that information. He may do it at present, but he does it too casually or not in sufficient depth and, as a result, it is not reflected in our factory systems.

Mr Blackmore said that the design, location and building of factories is looked at carefully but he also said the reason for this is that they want to employ the best people they can get. But having created the Utopia in which they could work, apparently they found it extremely boring. The fact is that work is not created for people, but people for work, and that is quite a different philosophy and attitude which affects the system.

Much was said about something called 'the system'; lots of different disciplinary knowledge and professionalism is involved, not just one discipline. Although today's activities are generally fragmented into specialist activities, the whole of the system is made up of team-work; each discipline must put in its particular bit of professionalism in order to achieve an integrated whole. The idea of a facility manager was also mentioned – someone to look ahead to see how changes can be accommodated with the minimum disruption.

I am not sure what we will get out of this. More questions were raised than were answered; in fact no questions were answered. No matter how the work scene changes in physical reality, there will still be a work scene which we will have to accommodate at some time or other within the buildings and artefacts which house people and machines. What I should like to see is a wider conference and seminar which might be directed to the concept of buildings for people as well as machines, rather than talking about the detail which architects are perfectly competent to deal with. The best way to do this is through discussion and debate.

David Firnberg made the statement that the place was not as important as the system itself. Ken Cure dealt with people and raised the important issue of retraining, which is an essential part of modern industry. That is what I thought our modern polytechnics and further educational systems were intended to provide but they do not do so on the scale the changing world demands. Continuing education is vital.

So my suggestion to the RSA-Cubitt Trust Panel is that it starts to organize another conference for people to talk about machines and people and buildings.

MR SHERBAN CANTACUZINO (Chairman, RSA-Cubitt Trust Panel): I should like to conclude this fascinating and enlightening discussion by thanking Sir Monty Finniston, the six speakers and all of you who came and contributed. Let me assure you that the RSA-Cubitt Trust Panel will do its utmost to carry forward the dialogue which has been started to-day.