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MICROELECTRONICS

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INTRODUCTION

This Report concludes Part One of a fact-finding exercise set up with the aim of helping define promising areas of multi-media educational provision in the area of new technology - and in particular microelectronics. It is a distillation of impressions gathered in the last nine months during visits in Britain, the U.S.A., Sweden, Norway, Holland and Germany. These will be augmented in 1980 after a visit to Japan, where microelectronic penetration is probably greatest and where manpower planning to cope with its anticipated effects is said to be well advanced.

The purpose of all these visits by staff of the B.B.C. Continuing Education Television Department, has been to obtain a broad and non-parochial view of the way in which the new technology is being applied, and, in so far as it is possible, to judge what the likely implications might be for the shape of employment and for the education and retraining services.

The B.B.C. Continuing Education Television Department is probably unique in its ability to address a wide range of audiences, both general and minority. It has a good deal of flexibility when it comes to producing back-up material to support its television series. It also has much experience of extensive collaboration with outside agencies. The present aim is to make an informed decision about where limited resources should be used in the next few years in producing materials to help either special groups or the more general audience come to terms with this unpredictable but rapidly developing technology.

Background note

It was probably the BBC's HORIZON programme 'NOW THE CHIPS ARE DOWN' which in 1978 first raised public awareness of micro-electronics. It certainly helped galvanise the Callaghan Government into positive action, stimulating the Department of Industry's awareness programme for managers and the Microprocessor Applications and Developments Projects. During the winter of 1979 this department recognised the importance of microelectronics and decided to mount a general awareness series (to be transmitted early in 1980): THE SILICON FACTOR. This is being backed up by a pack of material from the National Extension College.

During the winter and spring of 1979, there were innumerable conferences on microelectronics built round a small circle of pundits. Those held under the umbrella of the Awareness Project and intended to stimulate industrial activity tended to be attended by representatives of the larger companies; only rarely by the unions. Others held at, for example, polytechnics, were often patronised by a wide range of people concerned with what had rapidly become a highly political social debate about the imminent collapse of work.

Against this background, it was interesting to compare the high level of public debate and the low level of industrial activity here with the almost complete absence of debate and a greater degree of positive acceptance of the new technology in other countries.

This could lead to one of two extreme views about Britain:

(1) We are relatively a more sophisticated society since we are already facing the issues raised by the prospect of manufacturing and service industries being able to function with 20% of the present workforce, and we are instinctively applying democratic checks and balances to slow down and reduce the traumatic effects of the microelectronics revolution.

Or

(2) we are squabbling in an unproductive way over the distribution of an ever-diminishing national cake, allowing others who unquestioningly accept new technology to sweep us even further from the world's market place.

In reality, of course, neither view is probably true. What is true is that there is confusion, uncertainty, and a good deal of dogmatic assertion about the microelectronics revolution.

This report is neither exhaustive nor rigorous in its analysis. But it does attempt to provide a disinterested view based on wide ranging conversations and observations.

Britain's vital need is to keep up with the development of this technology in manufacturing industry. Failure to do so will add another factor to our poor industrial performance. Clearly other factors will affect industrial employment far more than the shifts in labour requirements brought about by the effects of microelectronics alone. A deepening recession, poor labour relations, poor marketing and a worsening of the energy crisis are but four factors. Yet rapid adoption of the technology could do more than anything else to help us hold on to world markets.

(6) Within manufacturing industry microelectronics can be seen as an extension of automation and is likely to accelerate the fall in employment seen in recent decades while at the same time, altering the skills required by the remaining workforce. One major new feature, though, is the application to batch production where the flexibility of the new systems makes short-run automation possible (see later).

(7) It is the application of the technology to the service sector which has led to the greatest anxieties about jobs since this has been the major growth area for employment in recent decades. If we take a static view of services and assume the ruthless application of microelectronics, then reductions in the workforce of 50% or more could be possible. Two factors will reduce this:

(a) human resistance - militant or conservative in origin,

(b) the creation of new kinds of service, for example in the educational and personal welfare areas, or an increase in existing services.

Recessions apart, goods and services need people to consume them. This implies a high level of employment or an enormously high social wage (as in Sweden). So it is in the long term interests of those who control the new technology to seek to create new forms of employment or to encourage new patterns of work, paying people more to do less and less and reducing the need for full time employment as a prerequisite for self esteem.

THE TECHNOLOGY AND ITS POTENTIAL

(1) Moore's Law which has accurately predicted that the number of electronic components on a silicon chip will double each year is confidently expected to hold good for the foreseeable future. (Philips, Bell Laboratories, Texas Instruments). Improved computer aided circuit design and new methods of drawing the circuits using electron beams will guarantee this. By 1984 a million components on a silicon chip is most likely.

(2) The potential offered by microelectronics has led to other technologies developing in association with it. So the term 'the new technology' has to take account of this powerful synergy. Obvious examples are the development of cheap microscopic lasers (based on silicon chip fabrication technology) and complete fibre-optic telecommunications systems incorporating them (Bell Laboratories, New Jersey). These increase the possibility of a widespread rapid telephone data system which does not involve high capital equipment costs or the costly rebuilding of underground cable ducts. In a few areas complete fibre optic digital telephone transmission systems are already in operation (Chicago, Illinois Bell) and the U.S. seems poised to develop this, driven along by an expanding business demand for electronic data transmission.

(3) Magnetic bubble memories which are 'non volatile' and which have large storage capacities are already in some consumer products. Those commercially available have about the same capacity as their silicon equivalents, but bubble memory chips of up to 11 million are being made in limited quantities (Western Electric). Their disadvantage is their relatively slow speed of operation, but for many practical purposes this is quite adequate. So far bubbles have been incorporated in portable office terminals (capable of using slow data rates down the telephone line, through acoustic coupling) and in storing recorded messages in the telephone system. But at

present the storage of relatively large amounts of data still depends on mechanically operated magnetic discs, drums or tapes. However, it seems likely that the next year or so will see the incorporation of medium sized non volatile memories into more consumer products.

(4) The marriage of small scale laser technology with micro-electronic control has led to the design of the commercial video disc (Philips) already on sale in the U.S.A. An extension of this has been the development of the digital data disc which can record 10^{10} bits of information on a single 12" disc and can search and find information almost instantly. This is a powerful piece of technology with considerable potential applications in any data processing area. The fact that I.B.M. and Philips are working together on the video disc suggests that the former wants to incorporate the data disc technology into its business systems.

(5) Pattern Recognition. Prototype robot manipulators already exist which can recognise patterns and manipulate objects presented randomly to them.

Typical is one from Philips which can be taught to recognise a part and pick it up however presented in a flat plane. This kind of machine could easily perform simple assembly tasks where the part arrives randomly but needs to end up in a precise place. In the course of the year, General Motors introduced a pattern-recognizing robot in their production lines at Illinois. This is being used to pick up hot metal parts. General Motors have predicted that 90% of their production processes will be 'computer controlled' by 1980.

New camera techniques exist which produce an instant 'digital' picture of an object which a computer can quickly recognise and it seems likely that these will be incorporated soon. Programmes for such machines are now becoming more sophisticated, so that new parts

will only have to be shown to the machine once. Further away is the machine which can not only pick up a randomly presented part but position it correctly even though the final position itself may vary.

(6) Voice Synthesis and Recognition. Word assembly using the digitally recorded components of human speech is now an established technology (Texas Instruments). The results no longer sound like 'computer speech'. Although a little flat, they do sound human.

Speech recognition is much less well advanced. Under controlled laboratory conditions speaker independent systems (where the computer recognizes any voice) can perform simple tasks (e.g. recognizing a name, letter by letter and then looking it up in a directory and giving the telephone number). Speaker dependent systems (where the computer recognizes only a voice it has been trained to recognize) are able to cope with a limited vocabulary and are in use.

Neither of these seems to be sufficiently reliable to come into general use in the immediate future, though they do have applications involving simple commands (up, down, left, right etc.) where an operator needs to keep his hands free or is disabled.

(7) The major chip manufacturers make great play on 'the learning curve' - i.e. the rule of thumb which predicts that there is about a 30% yearly increase in the sophistication of any application of microelectronics. Thus today's gimmick toy becomes tomorrow's educational device. But it also means that in the area of applications - whether in industrial process control or in new product design, those already on the ladder have an advantage over those who are not, and are likely to maintain that advantage.

(8) In many ways the application of microelectronics lags behind

the potential it offers. This is clearly caused by:

(a) A lack of systems design expertise within companies not already in the electronics business

(b) Slowness in the design of reliable sensors and activators to go into microelectronic systems

(c) A conservative, ignorant, cautious or otherwise preoccupied market.

DATA PROCESSING

(1) The largest and fastest consumption of the new technology is likely to be in those areas where comparatively standard, comparatively cheap computerised equipment can be installed and used in data retrieval or data processing. The term 'data' can mean numerical information or text.

In the past the use of computers has been:

(a) in centralised operations in large organisations;

(b) restricted to dealing with large numbers of standardised operations, e.g. dealing with gas bills, drawing up salaries, issuing licenses etc.

The advantages in the past have been the economies of scale. The disadvantages have been in remoteness, inaccessibility and potential disruption by small groups. Centralised computer activity is prey to gross effects of the kind seen recently with the hold up of telephone billing and the log jamming at the Swansea Licensing Centre.

(2) The dramatic drop in the cost of computing systems will mean:

(i) a wider use in large and small firms and organisations,

(ii) an increase in decentralised computing,

(iii) an increase in the number and type of tasks which can be tackled,

(iv) a return to the small is beautiful (and more efficient) philosophy.

Falling costs increasingly open up a range of possible systems:

(a) small, local, independent computer machines, say in a small firm;
(b) small, locally linked computer systems, say in a suite of offices within a building;
(c) small, local computer systems linked to others via the telephone system;
(d) small, local computer systems linked to a larger, central computer via the telephone system;
(e) as with (d) but linked by satellite to other parts of an organisation, worldwide;
(f) as with (d) but linked by satellite to a range of organisations with common interests.

N.B. (i) The capacity of the telephone system to deal with data transmission rapidly and on a large scale may limit the spread of (c) and (d).
(ii) Political restrictions may limit the spread of (e) and (f), though 'dedicated' satellites are used at present within organisations like I.B.M. and Texas Instruments, the G.P.O. monopoly prevents communication between organisations using satellites. I.T.T. in America has just received permission from the F.C.C. to use its satellites as a 'common carrier'.
(iii) Incompatibility between computer systems may not be a serious problem.

Areas which will particularly be affected will be:

(1) Small businesses, who will increasingly use computers for financial records, stock control, invoicing, accounting and so forth. There is a rapidly growing market for small systems in Britain and in the U.S.A. Almost no company is too small to benefit. Information still needs to be fed in and looked up, and although the number of clerks required is smaller, those firms we have talked to say they find it difficult to find competent staff anyway. N.B. Many of the systems employed will be off-the-shelf or easily modified standard programmes. This is an area for the small scale entrepreneur, and

the get-rich-quick charlatan. The opportunity to buy the wrong system is enormous and many may burn their fingers. High street computer centres (especially in the U.S.A.) already exist to service the needs of the local business community. This is beginning to be seen over here. In America besides small businesses, professionals like doctors, lawyers and real estate agents are buying systems.

(2) Chain stores, where point of sale computer terminals record information during the day about what has been sold. This is relayed to a central computer periodically. This kind of system enables the company

(i) to compare the performance of individual stores and even individual cash points;

(ii) to alter its sales strategies for individual items which are not selling well;

(iii) to improve its stock control and streamline its ordering and payments systems.

Increased efficiency here can be great and can further disadvantage small shops.

Laser scanners in supermarkets have received a good deal of attention. Typically, where bar-coding is put on 80 - 90% of items (as in a Texas supermarket) the checkouts can deal with 50 items a minute instead of 30, and the customers get a better service. The system eliminates the mis-reading of price labels, responsible in the past for about 3% loss in takings. Potentially the savings in terms of staff could be significant. (Individual goods don't need pricing by hand, for example.) Large concerns like Tescos are already forging ahead, with computerised systems of this kind.

(3) Offices. Using the term 'office' in its widest sense, it is this area where the most serious displacements in employment may take place.

A distinction should be made between:

(a) simple text processors
and (b) management information systems of various kinds.

The text processor clearly involves a secretary in less work if she is producing drafts and redrafts of documents. But Parkinson's Law seems (quite seriously) to apply in offices using such machines: new tasks appear; more redrafting occurs, and so forth. There is often an increase in job satisfaction in that the printed work is better finished. Standard letters are quicker to produce and this could mean that a typing pool shrinks. However, the received view is that good secretaries and typists are difficult to find and that such equipment, at present, increases status and therefore attracts the good secretary.

The management information systems. These allow managers and secretaries to store the bulk of their information in electronic files and to be able to select and correlate information from them electronically extremely quickly.

It is this kind of system which may have the greatest effect on office structures, office politics and employment as well as on efficiency.

It has proved difficult to find really advanced examples of electronic offices. However, Citibank, New York, is an example.

Management and their secretaries have 'work stations' - linked electronic filing systems with adjustable screens and keyboards. Internal memos and some external correspondence are transmitted electronically. Letters (etc.) from outside are logged electronically but filed and microfilmed in the normal way. Citibank anticipates that digital facsimile copiers should be available in a year or so which can allow external correspondence to be rapidly recorded and stored in the filing system instead of on microfilm. I.B.M. say such systems are being developed by them and Rank Xerox are already producing prototypes. Printing of the few documents needed is by

daisy-wheel and ink-jet printers.

The crucial effects of the Citibank experiment has been that individuals can have responsibility for a much greater range of work. With the processing of letters of credit, say, one person now sees the whole process through, whereas before there was a production line of people processing different parts of the work. The productivity increase has been enormous - only 40% of staff now needed for this function. Individuals have greater responsibility for a process, but the work is more isolated. Work satisfaction has (apparently) increased; skill levels and responsibility levels and pay have gone up; redeployment and natural wastage has taken care of the people displaced. But Citibank is expanding and the whole situation is characteristically bullish.

They and others we have talked to agree that these systems:

(a) increase productivity dramatically (especially with electronic mail);

(b) reduce the amount of low level clerical and secretarial work;

(c) increase the skills levels but require fewer staff;

(d) produce an overlap between secretarial and management skills (secretaries can be asked to do more complex tasks, managers find themselves operating the work stations themselves);

(e) following from (d), there is a growing feeling that office (and indeed management structures generally) tend to become less hierarchical as individuals have access to a wider range of information and are asked to do more complex tasks.

Most of the mechanical skills involved in the operation of the more sophisticated systems are concerned with retrieval techniques. I.B.M. claim these can be learned in a few days by a competent secretary. More significant is the increase in the range of things she can do and the speed with which she can do them. The second rate secretary or typist may be edged out. In other words there is a need

for increased general competence. It is the larger and heavily stretched firms (like the multi-nationals) which seem to be installing these machines faster than anyone else. It is also the larger firms which can cope with redeployment more easily and with the retraining necessary.

The most immediate applications seem to be:

(a) accounts,
(b) invoicing,
(c) ordering,
(d) stock keeping records,
(e) personnel records,
(f) internal memos,
(g) producing external correspondence.

Software

Office procedures are fairly standard. Consequently standardised computer systems will be readily available (in many cases are available) for many routine clerical and other administrative functions. Minor modifications may be needed to tailor a system for a particular customer. Many equipment suppliers will offer this service but there is a small cottage industry here for independent business computer consultants.

Other Effects

(1) Working Conditions. Some V.D.U. screens flicker, have poor character definition or are badly positioned. Where these have been installed (e.g. in one Swedish newspaper office) there has been resentment. Others are bright, sharp, adjustable and have been the subject of consultation with employees. There seems to be no evidence that well designed systems produce any more fatigue than the ordinary typewriter. But there is evidence that early consultation pays off.

(2) Decentralisation Distributed computing can lead to a reduction in 'head office' activity with major decisions taken more at a local level, if managers have access to 'central' information through the network. The corollary is that there can be more monitoring of what is going on, more cross-checking, more correlation of information, the feeling of more supervision of the individual by other parts of the system. However, with distributed computing it is possible for local information to remain local - rendered inaccessible to other parts of the system unless released by a conscious, local decision.

(3) Polarisation There is some fear that middle grade office staff may suffer most and that filing clerks, lower management and supervisory staff for example, may be less in demand. There may be polarisation between the super-secretary/management strata and the menial levels concerned with the entry of data or making tea.

A note on electronic mail

No one seriously anticipates a very rapid explosion of electronic mail using high speed digital transmission. In the U.S.A. there have been limited consumer to consumer fibre-optic systems, but even within the Bell Telephone Company, they talk of 10-15 years before the network is extensive. However, a widespread use of slow data transmissions of mail using the standard lines is expected within and between large companies within 5 years, and the use of satellites is growing. The long term effect on the postal services is considered serious since there, as here, 70% of mail is business mail, and this supports the domestic service. Within the postal service certain processes (such as the Dutch automatic post code reader) are being automated, but the service itself is so labour intensive that costs are bound to rise sharply, increasing the incentive for cheaper, more immediate message transmission. Ultimately the use of Viewdata systems as a total substitute for traditional mail cannot be ruled out. But in the medium and short term, it is likely that Viewdata will increasingly be used, largely in business

as an alternative for the transmission of many services otherwise conducted by mail. The domestic market is likely to grow much more slowly. Thus, stock information, credit transfer, bank balance enquiries and so on, will be provided on an ever increasing scale. Electronic systems will probably slowly usurp the position of traditional mail and its survival will be a political question - rather like the maintenance of railways in remote areas. Even without Viewdata, the Germans say that 5% of mail could be transmitted electronically now between established communication partners and that this figure could reach 50% with the introduction of public access terminals.

The social effects of a massive increase in electronic mail (pending the milennium when everyone could have a portable Viewdata terminal) might be serious - personal mail could be priced out of existence.

(4) Financial Services Here is a typical area where there are conflicting views about the impact of microelectronics. Those in banking are optimistic; those outside suggest that areas like this are indeed vulnerable because the micro-computer is going to be much more job displacing than the large computers in use now. Many banking and insurance transactions - as well as those in related areas - like building societies - are highly defined and therefore capable of automation. The predictions being made about the effects of new technology are confused. Spokesmen in the U.S. and Germany suggest a drop in total employment. Those in Holland and the U.K. predict stability or a small increase. Different countries have different banking systems and different patterns of public demand for banking services. The Japanese are cash orientated far more than the Americans; English banks are national, American banks are regionally based, and so on. In Britain 60% of us are still paid in cash rather than by cheque or credit transfer. In Holland it is 95%. We make 95% of our payments for services and goods by cash and of the 5% non-cash payments, 60% are made by cheque and less than 10% by credit card. So the completely electronic methods of payment are at present rather

insignificant. Clearly, they could grow enormously; but if public preference is anything to go by, the prospect of the cashless society is a long way off. British banks are still anticipating an annual increase of 10% in the demand for banking services and are using automation probably more extensively than in other countries. They predict that employment will stay fairly constant or go on rising and that new technology will be essential to cope with increased demand and to provide new services. But those services, designed to increase banking activity, may have serious effects on other sectors. Thus if banks start providing computer bureau accounting services, the competition may be damaging to traditional accountants, already being affected by small business accounting systems.

Within Banking

(1) Cheque clearing - already highly automated - still has activities which are labour intensive (machines cannot yet read handwriting). The Cheques Act requires banks to send cheques back to the branch where the account is held, where they are checked again. It would need legislation to allow for changes here.

(2) Cash dispensers may be on the increase, but they are expensive to install and since the cost of the microelectronics is minute compared with the overall cost of installation, cheapening of the price of chips will not have much effect. They do reduce the counter load, though, which is rising year by year.

(3) Banks anticipate deskilling at sub-branch level because increased overall services and volume of trade will encourage specialisation, and most of that will be at the larger branches.

(4) They also point to the way in which skill requirements will change and that the secure job from age 16 to retirement may be a thing of the past.

Building Societies

Probably are more open to computerisation than banks, some having lagged behind. This is particularly true with cash withdrawal -

a notoriously slow procedure.

Overall, the major questions are these:

(a) Will almost every job involving the transfer of figures or information on pieces of paper eventually mean the use of some kind of electronic transmission? If so, what will be the net effects?

(b) Will changes in banking habits be led by technology or by fashion? i.e. even if the banks wanted it, could the cashless society be forced on an unwilling public?

(5) Other, Professional Areas -

(a) Accountants The spread of cheap systems enables smaller and smaller accounting firms to offer faster computer services. Yet the volume of work to be done will probably stay constant.

(b) Solicitors Many already use word processors to speed up the drawing up of legal documents - thus using fewer staff. To offset this, some are beginning to offer extra services, like personal financial advice.

In the U.S. some case law is computerised. Here, there is talk of computerising the land registry. The future depends on the profession itself - which is notoriously protectionist. Although lawyers themselves will survive, their employees (mainly women) may well reduce in number.

(c) Architects The advent of computer aided design has already reduced the number of draughtsmen employed in architect's offices. It is also beginning to worry the smaller architects' firms since if they cannot afford C.A.D., they are less likely to obtain lucrative local authority contracts, and be left with conversion work.

C.A.D. itself enables architects to try different solutions to a problem (for example to work out designs to use the minimum of materials or produce the minimum of heat loss). Designs are adapted on the screens using light pens and scale drawings are produced quickly and automatically on paper. Within much modern building design, 70% of costs is in building services (ducting, drainage etc.) C.A.D. can significantly cut down these costs.

(d) Quantity Surveyors We include these because they exhibit an interesting tendency - which may be seen in other middle range professional or white collar groups, that is to seek to increase the range of their work to compensate for the effects of new technology. They are arguing that if their work shrinks because much of their calculations can be made electronically, then they should have more responsibility on the building sites themselves and should become project managers, supervising the use of materials.

N.B. Computer design can be extended to produce critical path analysis for site operation. Older site managers are apparently highly suspicious of such techniques at present.

The Mobile Office

Work at home and on the road

The recent introduction of portable, computerised office machines which can store and send digital information down any telephone line, receive it back and produce a print out, is very significant since it means that many salesmen, businessmen, journalists etc. can have much stronger links with their offices. Indeed, it already means that a businessman working at home can call up any information from his files without the intervention of a secretary, by dialling direct into his office's electronic system. This is already happening at Citibank with senior executives.

The machines are capable of keeping records of transactions made by salesmen during the day, and the salesman himself can prime the machine with the latest stock information, by telephone, before he leaves home in the morning. Insurance salesmen can obtain and confirm on paper copy, quotations and cover notes, simply by using the nearest telephone and the portable terminal. Some journalists are already filing copy down the telephone line using such machines. In Los Angeles the copy can go straight into type. The acoustic couplers are simply fitted over the telephone ear and mouth pieces, and can literally be used anywhere.

Clearly as such systems become more sophisticated and the office based systems with which they link become more widespread and more reliable, their effects on patterns of work could be profound. Greater mobility, more work at home, shrinking of the need for office space, and so forth. It is another example of technology (cheap technology) which is already available making quite dramatic changes possible quite quickly. Will shortage of energy encourage more people to stay at home to work? Whatever the speed of change it does seem important that people studying business courses should have experience of such equipment and that planners should consider the effects on the need for office accommodation.

These are just a few areas where what loosely can be called data processing techniques are being applied. All seem to offer scope for increased productivity and for increased opportunity for new applications. The net effects on jobs is anybody's guess; the resulting social changes, the acceptability of the technology depends on the speed of change. There is, however, a need for vigilance - particularly in connection with data privacy and the various personal freedoms which might be threatened if there is widespread linking between computerised record systems. In the U.K. we have the recent legislative safeguards of the Consumer Credit Act, but that is all. In Sweden there is comprehensive legislation on data privacy which requires the licensing and monitoring of computerised record systems and bureaux of all kinds in both the public and private sectors.

Any computerised records system needs to be carefully protected from abuse. For good professional reasons access by the public to

all files held on them is clearly unlikely to be agreed by, say, lawyers and doctors (even though access is given to individuals to their credit files under some circumstances). The danger is of covert correlations which undermine freedoms in an insidious way.

Compatibility of Computer Systems

Different computer systems have their own idiosyncratic languages. Recently, however, organisations like Computer Analysts and Programmers in London, have developed 'translation' devices which mean that one system can 'talk' to a different one through an intermediate black box.

MANUFACTURING INDUSTRY

Manufacturing industry is being affected by the new technology in several ways:

(a) in production process control,
(b) in computer aided design,
(c) in the management of energy,
(d) in new machinery - computer controlled numerically controlled equipment,
- robots of a range of complexity,
(e) in improved products,
(f) in new products,
(g) in office administration,
(h) in stock control, materials handling, and warehousing,
(i) in work scheduling.

(1) From the point of view of the economy, the use of micro-electronics in industry is vital to improve the speed and quality of production, to facilitate the ordering and handling of materials and to improve products.

(2) Although micros can be labour saving in the production process, some would argue that (as in Japan) this releases people for work on quality control. The extent to which this happens depends on management philosophy about quality rather than unit cost, and whether (as in Japan) firms are obliged to retain workers displaced by automation.

(3) Tragically there is a lack of the kind of electronic systems expertise within many industries which is necessary before micro-

electronics can be used. As opposed to office automation, most industrial applications require unique solutions.

(a) There is an urgent need for more electronics engineers familiar with the needs of specific industries. University output is inadequate and even the present state is not guaranteed.

(b) There is an urgent need for much more education of other engineers about the way in which electronic solutions might be applied in their own disciplines.

(c) There is an urgent need for more links between small firms not in the electronics business and reliable organisations able to provide electronics expertise. This is an area where university and polytechnic departments of electronics could be given more positive encouragement to take on much more development work to 'service' the industrial community. It would also help to finance the departments at a time of short-sighted cheeseparing, and this might enable them to take on more undergraduates without alienating the rest of the academic community or the S.R.C.

(d) There is an urgent need for a greater understanding of the opportunities by top management.

(e) There is an urgent need for much earlier consultation with the unions to prevent later disruptive action.

(4) Process Control

Microelectronic monitoring or control of production processes may be considered a further extension of automation. But it has certain advantages over traditional automation:

(a) It reduces the need for simple supervision of specific parts of the process.

(b) It increases opportunities for anticipating breakdown, thus saving materials.

(c) It can deskill many previously skilled activities (such as the rule of thumb control of processes where several variables apply).

(d) It can co-ordinate various related processes to minimise the secondary effects of breakdowns.

(e) It can increase the speed of plant well past the limits for human supervision and control.

Examples of established process control in industry have been difficult to find - not only in Britain. But the impression is of a greater awareness of possibilities abroad with some companies (largely the multinationals) able to forge ahead because of the relative availability to them of electronics engineers and also because of a more active investment policy. They start from strength.

However, although the system development costs may be high, the capital costs involved in installing microelectronic control is low, particularly if existing plant can be modified.

Applications here are liable to produce some upgrading (e.g. of supervisors) as well as some deskilling. The polarisation effect again.

(5) Computer Aided Design

Lead times in the design of parts can be drastically reduced (especially with complex 3-dimensional designs) using computer aided design. Typically designers use V.D.U.s with light pens to alter designs and try many alternatives which by traditional methods would be extremely time consuming.

Design information can be held electronically and fed directly to computer controlled machine tools which can make prototypes quickly without the need for working drawings. The same techniques can be used to produce production moulds or dies.

Clearly this speeds up the gestation period for new products or new models. But it is likely to alter the skills of those involved.

Designers will need to be more skilled; fewer people will be needed to draw plans, machine parts and so forth. This is polarisation again, with the semi-skilled craftsmen suffering.

(6) Energy Management

This is an important side issue. Most micro-controlled processes can save energy by optimising production. But the management of space heating in factories by intelligent systems could save vast sums. Lucas reckon that they could save £5 million a year if all their factories were efficiently heat-managed. Employment here for maintenance men? Such systems need many environmental sensors.

(7) Britain has tragically lagged behind in investment in (as well as production of) modern machine tools. The new generation of computer controlled machine tools are more versatile and self-checking. The present time is a good time to invest in CNC machinery but considerable re-skilling will be necessary. Typically the (misnamed) programming of such equipment (entering the co-ordinates which the machine then follows as well as entering instructions) involves abstract skills of a kind new to the traditional machine tool operator. Increasingly, though, programmed tapes produced by designers could be used to load into the computer and the machine tool operator could become a minder. In practice operators will probably be able to overrride the computer and intervene to modify programming. But the skills will still be new ones.

(Note: In Sweden we saw technical college students learning how to programme very simple N.C. machines to mill their names in wood, and then having access to more sophisticated modern equipment. Where are the comparable British examples? How can our colleges afford to finance this kind of work in the present climate?)

(8) Robots

We have seen multi-purpose manipulative robots capable of being programmed to complete a large range of tasks - milling, drilling, finishing etc. on a variety of different parts. Welding and paint-spraying are better known, but the same principles apply. Such robots are capable

of short run batch production, since by the use of sensors which detect which of a range of parts is being presented to them, they can change instantly from one programme to another. Machines like this are still in limited use. (Sweden has 30 times as many robots, proportionately, as Britain, but this is still not many.) The jobs replaced have been semi or unskilled, (largely done by women). A typical robot of this kind can be bought off the shelf and easily modified. The 'programming' skills are similar to those of the CNC machines: higher level skills leading to polarisation again. (N.B. In Sweden jobs lost to such machines are those the factories say they otherwise find difficult to man. Often they are done by immigrant guest workers and are extremely monotonous.)

Note: One of the received ideas about microelectronics is that small companies can benefit as much as large ones since the add-on cost of computer control in batch production is small. In practice it seems much more likely that big companies will still have the edge because of their ability to make the initial investment, even though, typically, the 'pay back' time is only 3 years and the quality of the work done by a robot is more consistent than by man.

Groups of robots acting co-operatively are also being used in noisy, heavy industrial environments to assemble (e.g. electric motors) and especially to handle hot parts.

The Swedes take a pride in customerisation, and many of these heavy industrial tasks are again batch production. All the robots can switch from one product to another instantly. The discontinuities in batch production are drastically reduced.

Automatic factories

We were refused permission to see Sweden's first fully automatic factory, but a printed account was provided and is attached.

The Japanese are, of course, advanced in automation and there are rumours of a fully automatic diesel engine plant being built. This needs more investigation.

(9) Improved Products

Clearly there is a limit to the number of mechanical products which can wholly or partly be transformed with microelectronics. But many can be made more cheaply, be more reliable and can be more versatile than before, if the firms 'go micro'. Typically, new kinds of assembly jobs are created and unskilled workers often transfer to these fairly easily, though there are fewer of them. Those less easily accommodated are the more skilled toolsetters (etc.) no longer needed to make those mechanical parts replaced by their microelectronic equivalents. But some manufacturers have told us that the increased versatility of their micro products has actually led to a slight increase in the numbers employed. A good deal depends on what fraction of the old product is replaced by microelectronics and what fraction of the new results from increased sophistication of function.

A good deal has been made of the traumatic effects on the Swiss watch industry of the advent of microelectronics. But there are not many wholly or even largely mechanical products still being made which are likely to be similarly affected. Even so, many could be improved at little extra unit cost by the incorporation of micros. The danger is of foreign competitors improving their products first.

(10) New Products

(a) Here the picture is not all that good. There has been a flood of toys and calculator-like machines recently (few of them British) which can be considered new. They will continue to become more sophisticated but will bring little comfort to firms making traditional products in a time when there may be increasingly less money to spend on goods generally.

(b) The making of sensors and activators for microelectronic systems is one area for expansion - and alert small companies could benefit. But because the development of these devices may often be intimately tied-up with the elaborate systems design which only large companies can afford, and since there is a greater tendency for

large companies to subcontract less and less as vertical integration takes place, this may not necessarily follow.

(c) Some German industrialists, for example, seem to be saying that the risk involved in developing completely new products is so great that they do not anticipate many of them in the next decade or so. Companies like Philips, though, seem to be so concerned about Japanese competition that they say they are putting their faith heavily in new products (like the video disc, compact disc (the replacement for the gramophone record) and the data disc). In contrast, Seimens is remarkably conservative.

The claim is often made that the Japanese are good at taking existing ideas and improving them, but not good at innovation. Whether the compartmentalised industrial work styles with little or no mobility of individuals between companies explains this, remains to be seen. Most innovation at present seems to be coming from America or Europe where investment in research and development is high.

(d) Even if there were plenty of new products just round the corner, most of them would probably involve the use of highly automated production techniques and not be large sources of employment. (Philips video disc manufacture is likely to be at Blackburn: only 200 new jobs).

(11) Office Administration

All manufacturing industry involves office work. The processing of orders, invoicing, organisation of production scheduling and so forth lends itself greatly to the application of new technology (see the Data Processing section).

In an unpublished report, Seimens estimated that within offices there could be a productivity increase of at least 40% using computer systems. Within an industry with static production, this must lead to fewer being employed. Within large companies, automated warehousing of pre-packaged goods and computerised stock control can go hand in hand. The main advantages seem to be in reducing paperwork, in the easier handling and location of goods and the more streamlined management of stock levels, through better forecasting of the ebbs and flow of demand. The capital costs involved in establishing automation in the warehouse itself are high; those in the related administrative areas are comparatively small. It seems likely that, again, offices will be affected first.

(12) Within industry the ability of management to control and monitor the scheduling of work through the use of computerised systems can produce much more efficient production, a better flow of materials and reduce 'down' times. Typically, a worker will receive instructions on a screen about the next job to be done, the parts needed, the time allotted and so forth. In batch work, if certain stocks run low, the computer can switch production to keep work flowing. However, the psychological effects on the workforce of this kind of automation can produce alienation. The introduction of such systems requires careful consultation. In a typical example in Sweden, the workforce rejected the idea because it was thought that, rather like a production line, the machine would control the pace of work and 'spy' on workers. It also removed from the men a degree of skill in planning their work which they resented.

(13) Servicing

(a) Short term, while microelectronic products exist alongside their mechanical counterparts, service engineers are going, if anything, to require additional skills to deal with both sets of products.

(b) Long term, microelectronic products may produce deskilling. Since integrated circuits are impossible to repair, the tendency will be for repairs to consist

of the replacement of printed circuit boards rather than the step by step diagnosis of faults. However, if there is a growth in the use of electronic equipment, there will clearly be a need for more service engineers at least until the 'peripheral' equipment in computer systems is more reliable.

E M P L O Y M E N T

The Structure of Employment

(1) Historically technological advances have in the long term had a multiplier effect resulting in wealth creation and opening up many new forms of employment. However, in the short term there has also been an associated period of transition in which there has been structural unemployment. The length of this period and the associated degree of unemployment has been governed by factors other than the nature of the technology itself. The underlying question has always been whether or not the displacement effects of the new technology have been greater or smaller than the positive effects of the associated economic growth.

Our examination of this problem has through necessity been qualitive and limited to views on the next five years or so. Beyond that we have been able to form some speculative views. However, unless there is a dramatic change in the world economy, we believe that the displacement effects of the new technology will be greater than job creation effects, either resulting from the technology or from economic growth. The new technology is only new in the sense that it has recently become more powerful and cheaper to apply. The techniques have been around for some time, but it is their broad application which is important now.

(2) There is evidence to suggest that over the past ten years in countries with positive growth rates, there has been a net loss of employment in the majority of industrial and service classifications (Germany, Norway) and a net loss of jobs to the economies as a whole. This is a trend likely to be accelerated by new technology.

(3) As we have seen, in existing manufacturing industries, new technology is capable of reducing the design time, the numbers of components in products, improving the production process, leading to improved quality, saving of energy and materials and reducing bottlenecks and inefficiencies. In most of the examples we have heard of, there has been a net loss of employment. This has not necessarily resulted in direct unemployment as the adjustments have often been made through natural wastage and/or non recruitment. But this, of course, implies fewer young people entering the job market. Many of the jobs lost are those done by women.

(4) Of course new industries or products have resulted from the new technology - e.g. toys, t.v. games, calculators etc. However, the nature of the majority of these products is such that they are produced using the most advanced processes and their net contribution to employment is small, and largely abroad.

Many existing products have been enhanced by incorporating the new technology and companies have increased their sales, but, with some exceptions, where the enhancement has involved the reduction of mechanical components, net employment has remained stable or fallen.

(5) In the existing service sectors, there are more significant savings that can be made using the new technology. In the area of office and administration, productivity increases of around 50% have been regularly achieved (Citibank, Seimens, Salford, CEGB etc.) This has again involved net employment loss, although not necessarily associated with direct unemployment. The true effect of the savings is often understated as the new technology has often led to better service and/or an increase in the range of service.

(6) The productivity increases in retailing and distribution may not be as great in large organisations which already have computer systems, but there will be savings especially in the clerical and administrative areas. In small companies and businesses there will be greater economies, but these may not necessarily result in any significant effects on net employment.

(7) In the area of communications, it is more difficult to assess the speed of change and the resultant employment effects. Electronic transfer of information is already happening on an inter-company level, and certainly in the medium term, this is going to increase greatly - especially if distributed computing systems lead to decentralisation. One company guesses it will dispense with 70% of its telephone and postal communications when it introduces a decentralised computer system. (Tesco). The results are hard to gauge, but it is unlikely to result in any net increase in employment and will probably show a net decrease especially in the postal services, and later, in the longer term, in telecommunications service (although the manufacturing side of telecommunications will show an increase).

(8) Britain is not the only country to have become aware that microelectronics can be used to increase productivity and will lead to considerable structural changes in industry and services. What is apparent is that the responses in the countries we have looked at (with the possible exception of Holland) have been more conducive to the rapid introduction of the new technology than Britain. This has been mainly due to historic factors, e.g. high wage levels (Sweden, Germany) or because of a degree of national economic planning (Japan, France) or because historically they have been rapid exploitors of technology (U.S.A., Japan, Germany).

In many industrial sectors, Britain is not well placed for introducing the new technology because of traditional attitudes both to organisation (e.g. the low status of engineers in the decision making process) and to change. The average age of plant and machinery and the difficulties that already exist in industrial relations (see below) are also factors which will tend to slow down the introduction of new technology.

It seems likely that with any increase in world economic growth, Britain will have a relatively lower growth rate. However, it is unlikely that the world economy will experience growth rates which provide sufficient activity to absorb not only current unemployment levels in other industrialised nations, but in addition those employment losses caused by new technology. There is some

suggestion in Germany that a growth rate far above its average post-war growth rates would be necessary to achieve this.

Assuming that there will be unemployment effects in all industrialised nations, it is possible, unless there are reactive measures such as a reduction in time spent at employment (Germany is already advanced in coming to terms with this, with agreements on the reduction of the working week and increases in annual leave), that countries will introduce hidden forms of economic protectionism creating a more hostile environment for British economic activity.

New Economic Activity

There is a general consensus in all countries and between all people we have spoken to that the major areas which will see great growth and expansion are:

(a) the electronics and telecommunications industries,

(b) the leisure industries,

(c) education at all levels,

(d) the caring services, e.g. health and especially personal social services,

(e) cottage industry (e.g. crafts or clothing manufacture using cheap but sophisticated machines),

(f) transport. (But see page 21).

The speed and development of these sectors will depend on the degree of economic activity, the attitude of government, and the speed with which paid leisure time increases. At present conditions in Britain do not create an encouraging picture for any rapid expansion of these areas (with the possible exception of the electronics and telecommunications industries). Cuts in public expenditure here are in those very areas where the Germans, the Swedes, the Dutch believe there should be expansion.

Concentration

Concentration (sometimes called vertical integration) is likely to increase, especially in industrial production. The effects on many small companies will be significant. The reasons are these:

(a) Microelectronics can now be applied to small industrial processes with great benefits to efficiency. This theoretically could benefit many small companies. Many of these now do work subcontracted by bigger companies.

But big companies will be able to adopt microelectronics more rapidly than small ones because they are more likely to be able to find the development capital and, maybe, the expertise.

(b) Large companies may also be put into a position where the high cost of shedding labour encourages redeployment of those displaced by new technology. So they may increasingly take on work previously sent outside. (This is said to be happening in Japan and we have seen it here.) Or they may adopt the new batch production techniques and make products they had not made before, taking business from small companies. So the short term effects on small manufacturing companies could be bad.

Long term, though, small companies may have an advantage if they can capitalise on new technology and combine its flexibility with their own.

Competition

It is likely that competition will increase and that many of Britain's traditional markets will come more and more under attack from foreign competition.

(a) As information systems are developed it will become easier for customers to compare the price and performance of suppliers of goods and services (e.g. in the U.K. through Prestel). Conditions approaching pure competition may develop in many markets and efficiency in communication will pay off. Companies will be able to respond more quickly to market changes through closer and continuous monitoring of sales and also faster dissemination of information in organisations.

(b) Increasing automation both in production processes and in quality control in manufacturing and closer monitoring of performance in the service industries will lead to a widespread increase in the quality of goods and services. This is likely to lead to a reduction in price premiums for quality of products and services, producing greater perfection in competition.

The Multinationals

The post war period has seen the development of greater world wide interlocking of national economies. The expansion of low cost process automation systems, integrated information or documentation systems, electronic payments and increases in competition will increase this trend. These factors will encourage organisations, especially the multinationals, to locate their production and possibly services away from high cost to low cost economies, retaining only those operations which require a highly educated workforce and dependence on a

sophisticated infra structure (e.g. research institutions) or where transport costs form a significant proportion of the product cost. The main significance is that the 'sovereignty' of government economic policies will continue to diminish.

Nature of Employment

(1) For most manufacturing industries, many commentators predict an increasing polarisation in the qualifications required from employees. At the upper end there will be the requirement for highly trained personnel, increasingly with first degree or equivalent as a minimum and at the other end, no qualification requirement except literacy. This will be a long term trend, but there are already some examples of this happening. (Norway, U.S.A., Holland.) Increasingly, traditional skilled and semi-skilled jobs in manufacturing will be displaced or changed by new technology. Whilst this is not a new trend, it is now capable of rapid acceleration. It is not necessarily an inevitable consequence of the technology, but the factors are very powerful.

(2) In the service area again, there will be polarisation between the highly qualified and those with minimal qualifications for data input. However, there is likely to be a relative increase in the need for people skilled in dealing with other people at a much more sophisticated level than at present - e.g. bank counter clerks counselling customers on financial matters.

(3) In all areas of economic activity, greater reliance will be placed on computer systems for decision making and for the provision of information. This could have two effects: one possibility is to increase the separation between the performing of activities and the planning, directing and controlling of those activities. The effect may be to reduce the need for skill and judgement and to increase the amount of monotony in many jobs, reflecting the tedium of traditional assembly lines. But in a more insidious way, the scope and pressures exist for this to happen in many areas on industrial and commercial life, and throughout all levels of the labour hierarchy.

Alternatively, individuals may be able to exercise a greater range of skills and have greater responsibility since more information will be available to them more quickly. (See the Citibank example, earlier).

It has been suggested that the first alternative results from a more hierarchical structure of command, and therefore the other from a more broadly based one.

Two illuminating examples. In the Swedish car factory owned by SAAB 'autonomous groups' operate the newly equipped robot welding assembly lines. These men have moved from being narrowly employed as welders to being responsible as a group for a range of activities: maintenance and programming of the robots, materials ordering and supervision, quality control and even control of the budget for their own part of the production process. Information comes to them from the central computer and they are constantly feeding and receiving information about component supplies, progress, quality and so forth through computer terminals. The new technology has created a whole range of new skills and responsibility - a range which in Britain might be more difficult to achieve because of restrictive craft practices and a different cultural background.

This needs to be contrasted with one Scandinavian factory we visited where much responsibility and skill has been removed from a group of workers. In this plant all the milling and turning machines have been linked to a sophisticated system. Designs are made with a computer aided design facility and, once finalised, the production planning, scheduling and machine instructions are all computer controlled. The operators, who are relatively highly trained, merely monitor the machines in case of unforseen breakdown. It is felt by management that human monitoring is necessary and should be carried out by skilled people. The workers reaction is that their skills are now obsolete and that the work is very monotonous.

INDUSTRIAL RELATIONS

Many unions fear that new technology will have other effects besides creating unemployment:

1. Increasing the frequency of upgrading and downgrading of jobs,
2. Producing substantial changes in job description and altering skills,
3. Diminishing the control of employees over their style of work,
4. Creating greater supervision by computer systems,
5. Requiring greater flexibility.

In all examples we have seen where change has successfully been implemented there has been very early consultation with the workforce accompanied by the provision of comprehensive information on the requirements and demands likely from the change. Consultation has enabled workers to negotiate modifications to the systems or job requirements at the planning stages which has had the advantage of ensuring the systems are smoothly introduced. Often the modifications have improved the efficiency of the system. Badly presented schemes have almost always been resisted.

In Norway the creation of 'data stewards' - union representatives with the responsibility of negotiating technological change - appears to be thought by both managements and the trade union to be helpful in reducing the danger of industrial conflicts arising. The 'data stewards' are trained by both management and union (cf. British Health and Safety Representatives) in the whole area of new technology. The 'data steward' often then becomes a member of the team implementing the new technology.

New technology will be significant in increasing the productivity of companies, and should result in greater wealth being generated. Unless employees are able to participate in a trade off between higher remuneration and better working conditions on one hand and the loss of their skills or demands for greater flexibility or of redundancy on the other, the introduction of new technology is likely to be fiercely resisted. It may also be that unless such a trade off takes place, the national distribution of income may be altered to the detriment of markets and the opportunity of developing new industries and services.

POINTS FOR DISCUSSION

AN AUNT SALLY

(1) Overall there seems to be little doubt that micro-electronics is a desirable technology, but that it will lead to considerable dislocations and structural unemployment.

(2) The extent of that unemployment will depend on the speed of change. Effects may be most drastic in the service sectors in the long run.

(3) Employment in manufacturing industry will continue to fall and the fall will be increased by the new technology. But paradoxically, failure to adopt the new technology could be an even bigger threat to jobs if we thereby lose competitiveness.

(4) People who are curious or anxious must be helped to understand the nature and the effects of new technology. It needs demystifying. The black box needs to become a grey box. It must not be thought to be understood only by an elite, let alone controlled by it.

(5) Education involving, or about, computing needs to be broadly based and not associated exclusively with mathematics or physics. Children and students in all disciplines need experience of computer based machines from an early age. Key-boarding should be in the secondary school curriculum (as the French propose).

(6) Will some people be disenfranchised in an 'information society'? What skills not taught today will need to be taught for tomorrow? If people need to be educated for change, what is the future role of most of our vocational training? What are the 'transferrable skills' everyone talks about but seems not to define?

(7) Industrial relations are crucial. Employers need to provide early information about the proposed introduction of new technology and take note of the real fears of workers about the effects.

(8) Employees need to be educated to understand what the new technology is and the extent to which it is capable of modification. In Sweden this is done in paid working time.

(9) Legislation similar to the Health and Safety at Work Act should be introduced - allowing for training, consultation and the provision of information at planning stages.

(10) Technology centres based on centres such as the Building Centre (London), The Technology Centre (Berlin) and the proposed Micro Information Centre (Holland) should be encouraged so that small firms can obtain help and advice on the introduction of new technology.

(11) Many more electronics engineers and other engineers with electronics systems knowledge and training need to be trained.

(12) University departments of electronics, electrical engineering (and other engineering departments) should be actively encouraged to become local centres of advice and should be able to take on more development work for industry and commerce than they do at present.

(13) Most areas of vocational training in further education (and higher education) should lead in training for new technology and not trail behind. Some way needs to be found to finance the equipping of (say) business studies departments so that they can anticipate students' future needs and prepare them to work with new machinery. The present climate could not be worse than it is for this kind of expenditure.

(14) There is a need to define more precisely what skills the new technology will require in different areas. This is extremely difficult to generalise about. But T.E.C., B.E.C. and the I.T.Bs should address themselves to the problem as well as to that posed in (12) above.

(15) There is evidence that employment may polarise in many industries, with semi-skilled jobs most at risk.

(16) Work needs to be done to find out what the effects are of distributed computing on the working patterns and chains of command in, say, the electronic office or in work scheduling schemes. Do jobs get more or less satisfying? Do hierarchies change? Is there a feeling of isolation of control and supervision or is there greater autonomy and increased job satisfaction? Do different systems produce different results? Can bad systems be changed or are they too complex or costly to change once installed?

(17) Natural wastage will probably be the mechanism by which most industries adapt their labour requirements (especially if unions are involved).

(18) It follows that there will be fewer people entering the labour market at the bottom end. The pool of unemployed youth may increase, therefore leading to disaffection, and potential political disruption.

(19) Inevitably there will have to be changes in the work ethic. Meanwhile we are approaching a dangerous transitional state and for various reasons the next 10-15 years will probably see major upheavals. So the maintenance of youth employment and other occupational schemes becomes all the more important if we are not to have a demoralised workforce. The direction of some of these schemes, though, may well need re-thinking.

(20) Much more active work needs to be done to look at ways of shortening the working year, week or day. Both sides of industry must see the eventual sharing of work as the only socially acceptable solution to any profound long term effects of the new technology, especially if the leisure industries are to be stimulated. The alternative is a polarised society, which is Orwellian.

(21) The whole question of data privacy and the control of information in data banks needs early political discussion and legislative control if individual freedoms are to be preserved.

(22) The worst scenario for the future is of a widening gulf between two parts of our society: those in satisfying work, who are in control of the technology and who can buy all the goods and services they need, and the disaffected and unemployed who in all senses are second-class citizens.

Long term, the major challenge is the creation of meaningful work for people and the fulfilling use of leisure time. The areas which appear to offer scope for expansion are by a strange irony the very areas suffering severe cuts at present: education, social services, the leisure industries. It may be that long term (the energy crisis permitting) man's greatest source of employment will be in personal services, the elimination of want and the improvement of the environment.

(23) All this having been said, if the speed of change is linear and not as fast as some people predict, society may adjust

without too much trauma. But many changes are likely to be exponential. This has the danger that in the next year or so nothing much may appear to be happening and the prophets may be accused of crying wolf. Some areas may feel the winds of change more rapidly than others. But those areas not affected today may be affected suddenly tomorrow. And once an industry 'changes over' to microelectronics the impact can be quite sudden and - in the absence of proper preparation - severe.

The National Museum of Science & Industry

Science Museum

Mr. D Allen,
19 Priory Road,
Richmond,
Surrey,
TW9 3DQ.

Date 19 March 1997

Our ref

Your ref

Telephone 0171 938 8158

E-mail r.smith@nmsi.ac.uk

Dear David,

Thank you for delivering the donation of BBC microcomputer equipment to the museum on the 11th. March. I have compiled and enclosed together with your copy of the MSC report a list of items in the package.

We believe this small collection, complete with the extensive documentation will be extremely useful in establishing the significance of the BBC's computer literacy project in any future research programme into the history of personal computers.

On behalf of the Science Museum I would like to thank you for you co-operation and interest in our collection.

Yours sincerely,

Rod Smith,
Assistant Curator,
Computing.

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FILE NOTE

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FROM R SMITH

DATE 12 March 1997

SUBJECT BBC COMPUTER LITERACY PROJECT

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LIST OF ITEMS LEFT BY DAVID ALLEN ON TUESDAY 11TH. MARCH 1997

ORIGINAL SYSTEM BOX/KEYBOARD ALLEGEDLY USED AS PROTOTYPE TO SET UP THE PROJECT (THE SERIAL NUMBER 146567 DOES NOT APPEAR TO SUPPORT THIS) by ACORN COMPUTERS LTD 1981

MASTER SYSTEM BOX/KEYBOARD S/n 01-AMB15-0010079 (this unit allegedly destined for the prince of Wales who failed to take delivery) by ACORN COMPUTERS LTD 1986

MONITOR - NO MANUFACTURER JUST A STICK-ON LABEL WITH THE NUMBER 8140029

JUKI 6100 DAISY WHEEL PRINTER No 614-420-59 TOKYO JAPAN (JUKI IND CO LTD)

TWIN 5¼" FLOPPY DISK DRIVE UNIT 1981 S/n04-D02-001252 BY ACORN COMPUTERS LTD CAMBRIDGE

MUSIC 500 SYNTHESISER BY ACORN COMPUTERS DESIGNED BY HYBRID TECHNOLOGY LTD S/n 03-ANV-02-0100081

WS2000 MODEM BY MIRACLE TECHNOLOGY LTD OF IPSWICH USED BY BBC FOR E-MAIL etc. BETWEEN UK & USA

DOCUMENTATION

ARTISTS IMPRESSION OF SYSTEM BOX/KEYBOARD
XEROX COPY OF NEWSPAPER ARTICLE COVERING THE WINNING OF THE TECHNOLOGICAL PROGRAMME OF THE YEAR AWARD
2 X BBC MICROCOMPUTER SYSTEM USER GUIDES
THE BBC MICRO TOOL BOX (AIDS TO MORE EFFICIENT PROGRAMMING)
BEYOND BASIC BY RICHARD FREEMAN
THE COMPUTER BOOK (AN INTRODUCTION TO COMPUTERS AND COMPUTING)
INSIDE BBC TELEVISION (A YEAR BEHIND THE CAMERA) PAGE 176 MAKING THE MOST OF THE MICRO PICTURES AND TEXT
TOWARDS COMPUTER LITERACY (THE BBC COMPUTER LITERACY PROJECT)
MICROELECTRONICS (A REPORT PREPARED BY ROBERT ALBURY AND DAVID ALLEN OF THE BBC CONTINUING EDUCATION DEPARTMENT FOR THE MANPOWER SERVICES COMMISSION DECEMBER 1979)
AMX PAGEMAKER USER GUIDE
AMX SUPER ART USER GUIDE
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SOFTWARE

BOXED WELCOME SOFTWARE CASSETTE AND BOOKLET
'IMAGE' COMPUTER GRAPHICS PACKAGE BY HOMERTON COLLEGE CAMBRIDGE (BOXED)
MAKING THE MOST OF THE MICRO PRE WRITTEN PROGRAMMES FOR THE BBC MICRO DEMONSTRATING DIFFERENT APPLICATIONS. STILL SEALED
'TAX CALC 2' THE WHICH INCOME TAXCALCULATOR 1983/4 STILL SEALED
SIX 5¼" DISKS IN BOX MARKED "SOFTWARE FOR HRH THE PRINCE OF WALES"
149 ASSORTED 5¼"DISKS CONTAINING APPLICATIONS - GAMES - DEMONSTRATIONS - RECORDS - DEVELOPMENT