THE IMPACT OF NEW TECHNOLOGY ON JOB DESIGN AND WORK ORGANISATION

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October 1985

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ACKNOWLEDGEMENTS

This thesis could not have been undertaken and completed without the help of a wide variety of people and organisations.

I would firstly like to thank all the staff at the Social and Applied Psychology Unit for their assistance and encouragement over the last three years. Special thanks must go to my supervisor, Mike Fitter, whose close attention to my work and constant support were invaluable; and to Chris Clegg and Toby Wall, not only for their generous encouragement, but also, along with Mike Fitter, for finding the time to read drafts of this thesis and make suggestions for improvements.

I would also like to thank the Economic and Social Research Council and Sheffield City Council's Employment Department for funding this research. The staff of the latter, particularly John Darwin and especially in the early stages of this research, provided valuable assistance, for which I am very grateful.

I must thank the companies where the case studies were carried out, and those within them, both for allowing me to carry out this research and for the friendliness and helpfulness they showed to me.

However, despite the not inconsiderable assistance given by all those mentioned above, my main thanks must go to Susan Corbishley, for reading, commenting upon and typing this thesis.

PUBLICATIONS ARISING FROM THE RESEARCH

BURNES, B (1984). Factors affecting the introduction and use of computer numerically controlled machine tools. In T LUPTON (ed) _Proceedings of the First International Conference of Human Factors in Manufacturing_. IFS (Publications): Kempston, Bedford

WALL, T; BURNES, B; CLEGG, C; KEMP, N (1984). New Technology, Old Jobs. _Work and People_, 10 (2), 15 - 24

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BERNARD BURNES

SUMMARY

This thesis is an examination of the selection, introduction, use and effects on job design and work organisation of a particular form of new technology: Computer Numerically Controlled machine tools (CNC).

Part One, Chapters 1 - 6, reviews the new technology literature and the historical development of contemporary approaches to job design and work organisation. From this examination, a conceptual framework is constructed showing the factors which influence and guide the choices that organisations make with regard to new technology. It draws special attention to the role played by the values, beliefs, self-interest and power of individuals and groups within organisations, and the philosophy and precepts of Scientific Management. The section concludes by describing the aims, objectives and methods of the research, and by examining the development of, and literature regarding, CNC.

Part Two, Chapters 7 - 10, presents case studies of the introduction and use of CNC into nine engineering companies, differentiated according to company size and product batch size.

Part Three, Chapter 11, presents the conclusions from the study. It firstly compares the case studies with each other, and then with the conceptual framework. It shows that the empirical studies supported the framework, but that two additional factors need to be taken into account: (a) that there is a need to recognise that those involved in the process of technological change can be "dazzled" by the technology, and (b) that the change process can be significantly affected by the competence of those involved. Nevertheless, the conceptual framework, and especially the influence of Scientific Management, are confirmed. The Chapter concludes by putting forward guidelines for the introduction of new technology.

INTRODUCTION

Since the late 1970s, there has been an increasing flood of books, articles, specialist magazines and radio and television programmes all devoted to the subject of "New Technology" (Benson and Lloyd, 1983). Some commentators believe that "we are in the midst of a revolution" (Rumelt, 1981, p1). Others believe that the changes which the new technologies will bring about are likely to be "evolutionary rather than revolutionary" (Bessant, 1983, p16). However, no-one seems to doubt that, whatever the pace of the change, new technology will have "a major societal impact" (Hedberg and Mehlmann, 1981, p1).

Quite obviously, and properly, this development has raised many questions, and these will be examined in Chapter 1. However, as an essential introduction to that examination, the development of new technology, its applications and the growing governmental and public awareness of it will be described first.

THE NEW TECHNOLOGY

Whilst the term "new technology" tends to be used to cover almost all scientific advances over the last 20 years, the development to which this title is most commonly applied and which it is said will have the main impact is the micro-processor - the computer on a silicon chip (Braun and Senker, 1982).

As one basic text has put it, "The Computer is a machine which automatically accepts, processes and outputs data" (Rackham, 1984, p 13). The computer has a long antecedence. In 1642, Pascal designed and built a mechanical calculator to aid trade and navigation (Albury and Schwartz, 1982). In the 19th century, Babbage designed a mechanical computer with data banks and the ability to repeat routines. However, due to the limitations of engineering at that time, it could not be built (Council for Science and Society, 1981). A number of developments in the late 19th and early 20th centuries led to the building of the first digital computer by Konrad Zuse in Germany in 1939 (Rackham, 1984).

However, it was the Second World War and the race to build the atomic bomb which gave the greatest impetus to computer development. It was the Manhattan Project, the American bomb programme, which can be said to have built the first generation of computers. The computer, ironically called MANIAC (Mathematical Analyser, Numerical Integrator And Calculator), was needed to do the extensive numerical calculations necessary to design and build the first atomic bomb (Albury and Schwartz, 1982). Its peacetime successor, ENIAC (Electronic Numerical Integrator And Calculator), was built in 1946. Like all the early computers, it was phenomenally costly and built on a massive scale: it used over 18,000 valves, occupied a large room and consumed considerable amounts of electricity (Council for Science and Society, 1981; Albury and Schwartz, 1982). Not unnaturally, there were few takers for these early computers. The breakthrough came with the development of the transistor in 1947. This provided a solid state substitute for the valve, which meant that the capacity of computers could be enlarged and the size and cost reduced (Wakeham and Beresford-Knox, 1980).

The first British commercial computer (LEO) was built by J Lyons in 1949, and was used to calculate the value of output from their bakeries (Land et al, 1983a). In the 1950s, the progress of the computer was further accelerated by the invention of printed circuits. Thereafter, computers became a viable proposition for large and medium-sized businesses, which in turn led to the rapid growth of the computer industry (Wakeham and Beresford-Knox, 1980).

Despite these developments, the computer was still a large, expensive and relatively inflexible machine. It was the United States Aerospace and Defense industries which changed all this. They needed small and flexible computers, and were prepared to pay for their development. Between 1958 and 1976, the United States computer industry received $350 million in direct aid from the military, and, in the late 1960s, this aid bore fruit with the invention of the micro-processor (Albury and Schwartz, 1982; Wakeham and Beresford-Knox, 1980).

The development of the micro-processor has reduced not only the size of computers but also their cost. By 1980, it was possible to buy a micro-processor for £1, and £200 would be enough to purchase a home computer more powerful than the first commercial computers marketed in 1950 and which, at present-day prices, would cost £1 million (Wakeham and Beresford-Knox, 1980).

The falling cost and size of computers has meant that their use has now become pervasive and has spread even into small businesses. Indeed, it seems that there is almost no activity to which the computer cannot be applied (Land et al, 1983a).

The application of the micro-processor

In general, micro-processors can only duplicate the functions of computers which have been available for the last two decades.

However, the cheapness and size of the micro-processor now mean that many of the theoretical prospects offered by the computer can now be realised in practice (Wakeham and Beresford-Knox, 1980). There are four areas in which micro-processors are having, and will have, an impact upon advanced economies.

The first area is the development of new products which were not previously available. These range from TV games, pocket calculators, word processors, to mammoth projects such as the Americans' "Star Wars" initiative. Perhaps the most widespread development has been the "home" computer. Sales of these have been enormous; in Britain, almost 1 in 5 households now possesses one (Large, 1984c; The Star, 28.2.1985; White, 1985).

The second area is where the micro-processor is being applied to improve existing products. These include the digital watch, the computer-controlled washing machine, the control of some functions within cars by computers, the electronic cash register linked to a mainframe computer, which can instantaneously link manufacturers, suppliers, banks and shops, and the replacement of electro-mechanical telephone exchanges by electronic ones such as British Telecom's System X (Sleigh et al, 1979).

The third area is the increasing trend towards automation. This is taking place not just in factories but also in offices and the service sector in general. In manufacturing industry, the Advisory Council on Applied Research and Development (ACARD, 1978) forecast that micro-processor technology would be applied in design, part manufacture, assembly, inspection and testing. They also predicted that robots, controlled by computers, would assume a major importance in many of these functions, indeed, talk of the peopleless factory is now commonplace (Crane, 1982). In fact, studies have shown that new technology will have a major impact on all industries (Braun and Senker, 1982; Gunn, 1982; Sleigh et al, 1979).

The office and service sectors, traditionally more difficult areas than manufacturing in which to introduce automation, are likely to be affected relatively to a much greater degree. In offices, this has become possible with the advent of such devices as the word processor, and in shops, the micro-processor means that such operations as the automatic billing of goods may become commonplace. In the area of the storage and retrieval of information, the computer is becoming paramount; conventional, paper, filing systems are disappearing. This development not only allows many people to consult the same file at once, but the people need not be in the same building or even the same country. Indeed, it is possible to envisage the automated office paralleling the development of the peopleless factory (Bessant et al, 1981; Giuliano, 1982; Sleigh et al, 1979).

The fourth area where the micro-processor is having, and will have, a major impact is in telecommunications. Electronic mail has already arrived. This is achieved by connecting computer terminals together using telephone lines, radio or even satellites, and transmitting a letter or document from one computer terminal to another without using the postal services (Bessant et al, 1981). A variant of this is exemplified by the Ford Motors' computer centre in the United States. The centre has six general purpose computers and 100 special purpose systems that are in use seven days a week. During the American day, they are used by Ford engineers in North America. During the night, they are accessed via a cable link-up and data processing system by Ford engineers in Europe (Shaiken, 1980). The same principle lies behind the development of portable computer terminals, which enable workers to link up with computers via the telephone when away from their office (Wakeham and Beresford-Knox, 1980).

Another major development in communications is taking place in the entertainment field, with the development of satellite and cable television (Ward and Blunkett, 1983).

As can be seen from a brief examination of these four areas, the impact of the micro-processor will be enormous. However, as outlined earlier, these developments did not spring up overnight; yet it is only in the last few years that governments and individuals have awoken to the potential changes that the micro-processor could bring about.

GOVERNMENTAL AND PUBLIC AWARENESS OF MICRO-ELECTRONICS

Whilst these developments in the field of computers were taking shape during the 1960s and early 1970s in America, the rest of the world, with the exception of Japan, seemed either oblivious or unconcerned. It was only in the late 1970s that Western Europe became aware that the micro-processor had arrived and would bring about massive change.

The report that shocked the French and other European governments into considering the importance of the micro-processor was "The Computerisation of Society: A Report to the President of France" (Nora and Minc, 1980). When this report was first published in France in 1978, it reportedly sold out within a week of its publication. There is little dispute that it was this report that sent shock waves throughout Europe and precipitated other Western European governments into commissioning their own research into the impact of new technology on their economies (Lynch, 1982).

In Britain, the Computers, Systems and Electronics Board of the Department of Industry commissioned a study at the University of Sussex in 1978 to assess the future developments in computing. The report (Barron and Curnow, 1979) called for greater government emphasis on and public awareness of both the problems and opportunities presented by the new technology. The government followed up these recommendations and published its own policy document, based on work by the Advisory Council on the Application of Research and Development (ACARD, 1980). In May 1981, a further government report was published as a result of a House of Lords investigation into various aspects of micro-electronics (House of Lords Select Committee on the EEC, 1981). This pointed to the need for the EEC to develop a community-wide strategy for new technology, as opposed to merely national strategies, in order to face the challenge of the American and Japanese computer industries.

Much of what was written in these reports bore fruit in respect to initiatives by the British Government to encourage the take-up and development of new technology. This began in 1979 with the appointment of a Government Minister responsible for Information Technology, and was accompanied by the Department of Industry's Support for Innovation Scheme, which in 1984/5 has a £250 million budget. In 1984, the Government launched the Alvey Programme to develop strategic initiatives in the field of computers, currently with a £350 million budget. The EEC has also launched its own scheme: the European Strategic Programme for Research and Development in Information Technology (ESPRIT) which has a budget of £400 million over five years (Large, 1984b; Commission of the European Communities, 1983).

In terms of public awareness of micro-electronics, much has changed. At the beginning of 1982, which the Government designated "Information Technology Year", a MORI poll found that only 17% of the British population were aware of what new technology was. By the end of 1982, the figure was 62% (Large, 1982).

THIS RESEARCH

The growth of public awareness of new technology has been paralleled by the publication of an enormous number of studies that have attempted, by a variety of means, to assess, explain, and predict its impact.

The problem for the researcher, or anyone else who attempts to make sense of this body of work, is - as will be shown in Chapter One - that it is large, confused, and often contradictory.* This is not surprising given that many studies are based upon secondary sources, that some are purely speculative, and that only some are based upon first-hand empirical evidence. Even in the case of empirical studies, the tendency is for these to be based upon visits to one or two organisations, carried out at a single point in time.* The problems with the literature are further exacerbated by the fact that many studies treat new technology as an isolated phenomenon which can be understood without recourse to the existing body of knowledge about organisations and their members. This thesis, by combining the new technology and organisational literature with empirical evidence, will hopefully overcome these problems.

The objective of the research is to examine the impact of new technology on job design and work organisation in order to develop a conceptual framework which can be used to understand and predict the effects of new technology in these areas. This will be done by:-

i) Reviewing the new technology literature and drawing out the factors which are cited as influencing its organisational impact.

ii) Describing the factors that have influenced the historical development of job design and work organisation, in order to demonstrate their relevance for contemporary theory and practice in these areas.

iii) Examining four contemporary approaches to work organisation and job design.

iv) Presenting nine case studies of the introduction and use of a particular form of new technology - Computer Numerically Controlled machine tools (CNC).

The structure of the Thesis

This thesis is split into three parts. Part 1 contains six chapters: Chapter 1 reviews the new technology literature; Chapter 2 describes the historical development of organisations;

Chapter 3 examines contemporary approaches to job design and work organisation; Chapter 4 draws together the threads of the previous three chapters and presents a conceptual framework for understanding the organisational impact of new technology; Chapter 5 presents the aims, objectives and methodology of the research; and Chapter 6 describes the technology that is examined in the case studies.

Part 2 contains four chapters which present the nine case studies of the introduction and use of new technology in the South Yorkshire engineering industry.

Part 3 contains the concluding chapter, in which the case studies are compared with each other, and are also examined in the context of the conceptual framework in order to show its strengths and weaknesses.

One last point needs to be made: the use of "he" throughout the thesis reflects both the reality of the male-dominated engineering industry and the clumsiness of terms such as "his/her" or "s/he" rather than any bias on the author's part.

P A R T   O N E

CHAPTER ONE

NEW TECHNOLOGY: A REVIEW OF THE LITERATURE

The objective of this research is to examine the impact of new technology on jobs and work organisation; therefore, this Chapter will review the main conclusions that have emerged from the literature on these two subjects. However, two other issues will be examined first in order better to understand some of the hopes and fears that new technology has raised. Firstly, and very briefly, the literature on its posited societal impact will be discussed. Secondly, and at greater length, the debate regarding the impact of micro-electronics on employment levels will be described. The issue of employment levels is, obviously, crucial to the discussion of job design and work organisation which follows it, because if new technology does lead to the "collapse of work", then these issues become irrelevant.

The Chapter concludes by arguing that the impact of new technology cannot be understood solely with reference to the characteristics of the technology itself, but needs to take into account the effects of wider organisational and societal factors.

THE SOCIETAL IMPACT OF MICRO-ELECTRONICS

The last two decades have seen the development of strongly contrasting views regarding the social benefits of scientific and technological development. For some, the progress of technology has become associated with a variety of contemporary problems, amongst them hazards to health and safety; pollution and the depletion of natural resources; conflict between civil liberties and national security; and the whole question of the nature of democracy within advanced societies. Others, whilst recognising the problems, have seen technology as the cure rather than the cause (Bell, 1974; Boyle et al, 1980; Martin and Norman, 1973).

Many of the hopes and fears about technological progress in general have been carried over into the debate on the impact of micro-electronics on society.

The debate about the effects of computers on society has been going on since the 1950s, but it has become more intense with the advent of the micro-processor. Many have seen the computer as an instrument which will create a wealthier and more open society. This development has been given many names. Muchlap (1962) saw it as the creation of a "Knowledge Economy"; Etzioni (1968) has named it the "Post-Modern Age"; whilst to Brzezeinski (1970) it is the "Technotronic Age"; and Dahrendorf (1975) has called it the "Post-Capitalist Era". Perhaps the best-known term is that coined by Daniel Bell (1974) who saw computers creating a "Post-Industrial Society":

> A post-industrial society is based on services. Hence, it is a game between persons. What counts is not raw muscle power, or energy, but information. The central person is the professional, for he is equipped, by his education and training, to provide the kinds of skill which are increasingly demanded in the post-industrial society. If an industrial society is defined by the quantity of goods as marking a standard of living, the post-industrial society is defined by the quality of life as measured by services and amenities - health, education, recreation and the arts - which are now deemed desirable and possible for everyone. (p127)

Others paint a less rosy picture, seeing computers as a threat to individual privacy and to civil liberties and leading to a lessening of democratic control of Western societies. In a number of countries, there have been growing calls for laws to protect individuals' rights where information about them is kept on computer. This has led to legislation in both Europe, including Britain, and America, to protect individual records which are kept on computer. However, in Britain, one of the areas for most civil liberties concern, the collection of data by the police and the security services, has been excluded from the Data Protection Act (Boyle et al, 1980; Home Office, 1984; Mahood and Mahood, 1977).

In terms of democracy, Bjorn-Andersen (1983) has stated that new technology is concentrating power in the hands of fewer people. This echoes earlier criticism by Dickson (1974), who sees computerisation as bolstering the power of a ruling elite. Elliott and Elliott (1976) have also seen new technology as reinforcing the power of existing institutions rather than allowing greater participation in decision-making.

As well as the discussion of civil liberties and democracy, there has also been considerable debate about the economic benefits to be gained from micro-electronics.

Coombs (1979) has argued that the role of science and technology is to ensure the best quality of life for all, and that the challenge of new technology is to ensure that all share its benefits and not just those who already have wealth and power. However, the Council for Science and Society (1981) has questioned whether this will happen. They have suggested that whilst it is possible to see the benefits to industry and commerce of new technology, the direct benefits to society as a whole seem open to doubt. There are others, of course, who disagree with this view.

The Institute of Management Services has stated that there "are significant national economic advantages to be gained from embracing the potential of new technology" (Wakeham and Beresford-Knox, 1980, p7). Sussex University's Science Policy Research Unit, in a report commissioned by the Manpower Services Commission, concluded that "the introduction of new technology is essential for Britain under conditions of international competition. The alternative is to drift into obsolescence and relative economic decline" (Braun and Senker, 1982, p 1.1). This view is shared by a number of other government and non-government-sponsored reports (Attenborough, 1984; Cowgill, 1981; Sleigh et al, 1979), all of which take the view that Britain's future economic welfare depends on the rapid adoption of micro-electronics.

Therefore, as can be seen, the hopes and fears for society that new technology raises are not only wide-ranging but also unresolved, and perhaps, at present, insoluble. However, it is in this context that the debate on job numbers, job quality and organisational structure is taking place, and it is the discussion of these issues which will occupy the rest of this Chapter.

THE EMPLOYMENT EFFECTS OF MICRO-ELECTRONICS

The issue which has perhaps caused most controversy and concern with regard to micro-electronics has been its effect on employment levels.

Three distinct views have emerged: that new technology will create more jobs (ACARD, 1980); that it will lead to the "collapse of work" (Jenkins and Sherman, 1979); and that, by itself, new technology will have a minimal effect on employment (TUC, 1979).

By and large, most of what has been written falls into one of these three camps: the optimists; the pessimists; and the agnostics.

The Optimists

Probably the most optimistic detailed forecast of the effect of new technology was that prepared by the American Management Consultants, A D Little, for, amongst others, the British Government (Wakeham and Beresford-Knox, 1980). The report, published in 1979, forecast that by 1987 new technology would provide a net increase of at least one million jobs in Britain, France, West Germany and the USA. The report concluded that 60% of the increase would be taken by the United States, and Britain's share of the remainder would depend on how quickly and extensively it responded to the challenge.

Warwick University's Institute of Economic Research has also put emphasis on rapid diffusion of new technology as being a job creator (Whiteley and Wilson, 1981 and 1982). Using a computer model to simulate the workings of the British economy, they concluded that if Britain could adopt micro-electronics rapidly enough to increase productivity by one per cent net per annum relative to its main competitors, then by 1990 an extra 420,000 jobs would be created. However, as the Department of Industry has recently pointed out, this would have only a net effect of creating 80,000 jobs, because some 340,000 jobs would be lost as a direct effect of introducing new technology (Attenborough, 1984).

In the United States, Leontieff and Duchin (1983) have concluded that micro-electronics will have a positive effect on employment. This was also the conclusion of the Australian Government's Committee of Inquiry into Technological Change in Australia (1980). The Organisation for Economic Co-operation and Development likewise appears to take an optimistic view of the impact of technical change on jobs in Europe and America, pointing to job losses being offset by job growth in the micro-electronics industry and to jobs being created in user industries (Beckler, 1982).

Many other writers and organisations share this optimistic view (Bennett, 1979; Hargreaves, 1982; Kassler, 1981; Sheehan, 1980; Wakeham and Beresford-Knox, 1980; Williams, 1983; Williams, 1984).

In addition to contemporary evidence, one of the main driving forces behind this optimistic view is historical evidence that in the past a link has existed between technological progress, economic growth and increased employment (Abramovitz, 1956; Kuznets, 1966; and Solow, 1957).

Nevertheless, there are those who would dispute that, in this instance, the past is a reliable indicator of the future.

The Pessimists

Jenkins and Sherman (1979), who start from a historical perspective, have produced a very detailed argument for stating that technological progress will no longer be linked to increases in employment but instead to decreases. They have concluded that by

1990, registered unemployment in the UK will reach five million, due to the introduction of new technology.

Jenkins and Sherman are not along in predicting job losses due to new technology; indeed, newspaper headlines such as:-

> "Robots threaten million jobs" (Large, Guardian, 28.12.1983)
> "New technology destroying jobs" (May, Guardian, 27.2.1984)

appear with alarming frequency. Nor are these stories based solely on speculation or prediction. A survey by the Policy Studies Institute (Northcott and Rogers, 1984) found that the introduction of new technology into British manufacturing industry had caused a net loss of 34,000 jobs between 1981 and 1983. The Department of Industry recently estimated job losses in manufacturing owing to the introduction of new technology to be between 50,000 and 90,000 up to the end of 1982 (Attenborough, 1984). However, they attempt to put this into perspective by pointing out that between 1979 and 1982 some 1.4 million jobs were lost in manufacturing owing to the world recession. The implication is that when world recovery begins, employment will again rise irrespective of the technology being used.

It is on this point, that future economic growth will lead to more jobs, that the pessimists take greatest issue with the optimists. There is a wide spectrum of opinion, from economic journals (The Economist, 1984), to government agencies such as the Manpower Services Commission (Brady and Liff, 1983), and even including leading Conservative politicians (Pym, 1984), who believe that new technology could create job losses in times of boom as well as slump. They argue that the productive potential of micro-electronics is such that only relatively few people need to be employed to create the goods and services necessary for society.

Indeed, paradoxically, the concept of "Jobless Growth" is at the heart of the argument by the optimists of the Post-Industrialist school, such as Bell (1974) and Dahrendorf (1975). They acknowledge that new technology will allow industry to produce more goods with far fewer people. However, they are optimistic about job prospects because they believe that just as manufacturing in the 19th and 20th centuries created jobs for those displaced in the mechanisation of agriculture, then so the service sector in future will provide employment for those displaced by the automation of manufacturing industry. However, their critics, whilst agreeing with them on "jobless growth", criticise their optimism for two reasons. Firstly, that it greatly underestimates the importance of manufacturing industry as a provider of employment (Cowgill, 1981; Mumford, 1979); and secondly, and most importantly, that jobless growth can take place just as easily in the service sector as it can in the manufacturing sector. In fact, new technology is likely to have a relatively greater impact on jobs in the service sector than manufacturing and, therefore, this area is unlikely to be in a position to provide jobs for those displaced in other sectors of the economy.

This view is supported by a wide range of research. In Britain, the Association of Professional, Executive, Clerical and Computer Staff have reported that, in a survey they carried out in the West Midlands, for every one new office job created by new technology, 50 are lost (May, 1984). A survey of Britain, Europe and Australia with regard to technological change has concluded that more blue collar and white collar unemployment is inevitable

(Hall, 1979). In Germany, Siemens, the giant electronics group, has estimated that 40% of all office jobs could be lost through automation. A French report suggests that 30% of all jobs in banking and insurance could disappear as a result of the introduction of new technology (Wakeham and Beresford-Knox, 1980). A similar forecast for jobs in Britain's financial sector has been made by the Institute of Manpower Studies (Rajan, 1984). Similar findings have emerged in Austria (Schenk et al, 1981); in Australia (Robson, 1979); and in America (Shaiken, 1984).

There are also many others, in Britain and abroad, who share the pessimists' viewpoint (Blatt, 1979; Council for Science and Society, 1981; Cooley, 1983; Jones, 1982; Young, 1979). However, the pessimists' argument, like that of the optimists, is by no means as soundly-based as they would like it to appear, and there are those who reject both these arguments.

The Agnostics

The agnostics are a somewhat disparate group who are held together not so much by a common belief as by a common disbelief. For differing reasons, they prefer either to reject the importance of technology or to take the view that it is not possible to predict its impact on jobs. Evans (1982) and Wilkinson (1982) believe that whilst some jobs will be lost due to the introduction of micro-electronics, others will be created, and that the resultant overall outcome will have less to do with the technology and more to do with the economic policies that governments pursue. Winch (1983) and Forester (1980) have also pointed to the importance of the overall economic context of particular societies in shaping the final outcome in terms of jobs. In Sweden, Eliasson

(1982) and Eliasson and Carlsson (1980) have concluded, using computer models of the economy, that new technology will have no effect on job numbers one way or the other.

In contrast to that view, Sleigh et al (1979) have stated that "the overall employment effect is virtually impossible to gauge" (p106). Sorge et al (1982) have made the same point: "A great number of studies have been carried out . . . However, no reliable assessment of the impact [of micro-electronics on jobs] has been possible" (P169). Indeed, having looked at the cases prepared by the optimists, pessimists and agnostics, it is easy to see why they take this view. As Land et al (1983a) have pointed out in a review of the literature, "it is clear that most of the judgments made by authors [re jobs and new technology] are based on their own preconceptions, and their forecasts are of doubtful value" (p163).

Indeed, even those studies that have used complex mathematical models to predict the employment effect of micro-electronics have not escaped criticism: "such simulations are highly sensitive to the assumptions employed" (Attenborough, 1984, p35). A similar view has been expressed by Barclay (1983).

Summary

However, regardless of whether writers fall into the optimistic, pessimistic, or agnostic camps, none seem to quarrel with the Rathenau Commission (1980) report on the impact of micro-electronics on employment in the Netherlands. The report concluded that more jobs would be lost by not introducing new technology than by introducing it.

As Stubbs (1980) has stated, such is the nature of international competition that failure by a country to adopt technical innovations at the same rate as other countries will lead to loss of home and foreign markets and loss of jobs in that country. Therefore, whilst there are problems in predicting the consequences of adopting new technology, there seem few problems in predicting the outcome of not adopting it. It is the fear that they might be left behind in the race to modernise that has driven governments in advanced manufacturing countries to adopt national strategies to encourage the adoption of new technology.

However, the British Government's strategy for new technology has come under increasing criticism (Huhne, 1985; NEDO, 1980 and 1984). The British information technology industry is growing at a much slower rate than in other countries and has not only been losing its share of the home and foreign market, but, significantly, employment in that sector has fallen by 12% between 1980 and 1984 (Large, 1984a).

In conclusion, it appears that the only widely-held view on the issue of employment and new technology is that more jobs will be lost by not adopting it than by adopting it. This does not mean that the debate on this subject is sterile, but it does mean that it may have to be carried out, as Evans (1982) and Wilkinson (1982) argue, in the context of the general economic and employment policies adopted by particular governments.

Important as the issue of employment levels is, equally important is the effect of technological change on the nature of individuals' jobs.

THE EFFECTS OF MICRO-ELECTRONICS ON ORGANISATIONAL STRUCTURES AND JOB DESIGN

For organisational psychologists, the main area of interest with regard to technological change is how it affects the individual worker and, through him, the effectiveness of the organisation.

There are two principal ways that new technology could affect the individual at work. The first is by changing the structure of the organisation: it may become larger or smaller; more or less centralised; flatter or more hierarchical; more or less bureaucratic. These changes can all have differing effects on the individual and on the effectiveness of the organisation (Child, 1984).

The second way is by altering the actual job that the individual does. It has been demonstrated that job satisfaction and performance are related to variety, task completeness and, above all, autonomy (Wall et al, 1984). The introduction of micro-electronic equipment may give the worker more freedom to control what he does and to develop new skills, or it could reduce his discretion, and fragment and deskill his job (Walton, 1982).

This section will examine what has been written about the effects of new technology: firstly, on the structure of organisations, and secondly, on the individual. However, it should be borne in mind that whilst it is useful to separate the organisational effects of new technology from its effect on individual jobs, in practice, as far as the individual is concerned, the result may be the same. This is because it makes little difference to someone if their job has been made more onerous because a new organisation-wide computer system has centralised decision-making in the company and thus reduced his, and many others', personal discretion, or if the job they do has been automated and that has reduced their decision-making scope, but not affected anyone else in the organisation.

Therefore, the inter-relationship between the design of individual jobs and the structure of the organisation needs to be recognised. This is especially the case with individual discretion, which is the area where most overlap takes place between job design and organisational structure.

The impact of micro-electronics on organisational structure

There appears to be little disagreement in the literature on new technology that its introduction will lead to organisational change. Rothwell (1984) has argued that it affects the total management system. Ahlin and Svensson (1980) have observed that it will lead to organisational change affecting all workers. The disagreement in the literature is not, then, about whether change will take place, but about the nature of that change. At the risk of over-simplifying what is a very complex, and confused, picture, there seem to be three distinct views on what changes will take place.

The first is that the introduction of micro-electronics will lead to greater centralisation of control - that is, more rigid bureaucratic structures with less discretion for those at the lower end of the organisation. The second view is the reverse of the first; that computerisation will aid decentralisation and delegation of authority. The third view is that whilst new technology will have an impact on organisational structures, the exact effect will depend on a range of other internal and external factors which are separate from the technology.

More centralisation of control: Bjorn-Andersen (1983) has argued that the introduction of computers leads to substantial power changes within organisations. He believes that computers will come to co-ordinate functions that were previously co-ordinated by people, and that this will lead to greater centralisation of decision-making by fewer people. This point has also been made by Hennestad (1982), who points out that whilst computers can lead to less human supervision, this is merely replaced by increased control by computers over what workers do.

Brady and Liff (1983) concluded from an examination of manufacturing companies that the introduction of computerised equipment onto the shopfloor resulted in the transference of decision-making farther up the organisational hierarchy. Blumberg and Gerwin (1981) have made similar comments about the introduction of new technology into American companies.

Wieser (1981), in a five-plant Austrian study, has also noted that the introduction of computers leads to a reduction in workers' discretion at the lower levels of the organisation.

Hennestad (1982), commenting on the effect of new technology on industrial democracy, has pointed out that computerisation leads to greater formalisation of practices and procedures, which results in more rigid and centralised organisations. Perrow (1973) has observed that computers do make it easier to centralise control, and in a later article (Perrow, 1983), he also noted that there is a tendency for senior managers to introduce new technology in such a way that it bolsters and extends their power.

This view, that computerisation leads to more centralisation of control, is shared by many other writers (Cooley, 1980; Lund, 1978; Lungren and Sageser, 1967; Whistler, 1970). However, there are others who disagree.

Less centralisation of control: Withington (1969) and Blau et al (1976) have suggested that computers will lead to the decentralisation of decision-making. Klatzky (1970) has also noted that computers allow the delegation of authority to take place. Land et al (1983a) believe that up to the 1970s, it was the case that computers led to the centralisation of control in Electronic Data Processing (EDP) departments. However, they point out that the advent of micro-computers has led to a reversal of this trend. Lucas (1984) denies that there was ever a tendency towards the centralisation of control in EDP departments.

Walton (1982) has pointed out that the cheapness and flexibility of micro-electronic equipment will lead to the decentralisation of power within organisations. Both Sell (1984a) and White (1983) believe that new technology will lead to flatter organisational structure, and Child (1984) has pointed out that this sort of structure is associated with more participative types of organisations.

As with the case for centralisation, there are many others who see computers leading towards more decentralisation (IR-RR Survey, 1984; Reif, 1968; Stewart, 1971; Tarling, n.d.; Warner, 1984). However, there is also a third view.

The case against technological determinism: Whilst there are many writers prepared to argue that new technology has a particular impact on the structure of organisations, there are others who would argue against such a determinist view.

Mumford (1979) has pointed out that, in practice, new technology is flexible and can be used in a variety of ways. Kemp et al (1984) have also observed that micro-electronics offers a wide range of choice in how it can be used, and that it would be misguided to adopt a deterministic view of its effects.

Sorge et al (1983) have reported that a variety of organisational arrangements can and do accompany the introduction of the same technology. Wilkinson (1982) has concluded that there is no general impact of new technology, and that its effects will vary from organisation to organisation, depending on their particular circumstances.

There are many others who share this view (Keen, 1981; Lay and Rempp, 1981; Nicholas et al, 1983; Robey, 1977; Rothwell, 1984), and the discussion of it will continue at the end of the next section, which deals with the impact of new technology on individual jobs.

The impact of micro-electronics on job design

The aim of this section is to consider the implications of new technology for the nature of the jobs that people perform. Writers have used a wide range of terms in describing the effects of micro-electronics on jobs: skill, control, variety, boredom, monotony, division of labour, responsibility, etc. However, in the main, these terms tend to be subsumed under the general heading of skill. Increased variety, responsibility and control for the individual are seen as increasing his skill and creating a better job. On the other hand, fragmenting the job, increasing boredom and reducing control are seen as reducing skill and thus creating a worse job for the individual.

Using the concept of skill, it is possible to separate the writers on new technology into three groups, in a familiar pattern: those who see new technology as deskilling people; those who see it as reskilling people; and a third group who believe that new technology does not, by itself, determine the level of skill and that, indeed, there are choices in how it can be used.

The deskillers: It should be said that no writer has suggested that everybody will be deskilled by new technology. In the main, the deskillers would adhere to Braverman's (1974) polarisation thesis. He argued that micro-electronics would lead to the vast majority of the workforce being deskilled whilst a few, at the top end of the organisational hierarchy, would be highly skilled and highly rewarded.

In reviewing the literature, there is much evidence to support this view. In Sweden, Ahlin and Svensson (1980) surveyed 16 engineering companies which had introduced new technology. They found that this led to a worsening of shopfloor jobs; there was an increase in job fragmentation, shift work and the use of unskilled labour. Artandi (1982), in America, found that the introduction of computers onto the shopfloor turned skilled workers into "button-pushers". She found that computers tended to mystify the production process for shopfloor workers and that this led to alienation. Blumberg and Gerwin (1981), also in America, come to similar conclusions. In addition, they found not only that the introduction of computers removed shopfloor workers' decision-making skills and put decisions into the hands of a few experts, but that this led to inefficient production methods which would not have been the case if skilled workers had been able to exercise control.

Dostal (1982) has observed that new technology is leading to skill polarisation in West German manufacturing industry. Cooley (1983), in Britain, has pointed out that deskilling is not isolated to the shopfloor. Such developments as Computer Aided Design can, he believes, result in the deskilling of draughtsmen and designers.

These findings are not just related to manufacturing industry; the deskilling of clerical jobs has been observed in the service and other sectors. Whistler (1970) has noted that the skill and discretion of white collar workers were reduced by the introduction of computers. Bjorn-Andersen commented that the computer introduced the "assembly-line effect" into the office; that is to say, it reduces workers' discretion and variety and also controls the pace at which they work (quoted in Hennestad, 1982). The HUSAT Research Group at Loughborough University found evidence that computers introduced into offices could have long-term adverse effects upon motivation, job satisfaction and career prospects (Damordaran et al, 1980).

Wynn and Otway (1982) concluded that even middle management were not immune. They found that computer systems that were supposed to aid them actually resulted in their being deskilled and alienated.

As well as noting a general tendency towards deskilling, particular groups have also been singled out as being more at risk. These include women (Williams, 1984) and older workers of both sexes (Ahlin and Svensson, 1980).

There are many other researchers who have also concluded that new technology will have adverse effects on job design (Hennestad, 1982; Lund, 1978; Lungren and Sageser, 1967; Mumford and Banks, 1967; NEDO, 1983; NOU, 1980; Senker et al, 1976).

<u>The skillers</u>: The viewpoint that new technology will maintain and increase skill is put forward by a wide range of writers from different countries. Aguren et al (1984) examined the Volvo car plant at Kalmar in Sweden and found that new technology had improved jobs. Forslin et al (1979), also in Sweden, came to a similar conclusion when examining another large engineering company. Lay and Rempp (1981) concluded that in West Germany the introduction of computer numerically controlled machine tools (CNC) tended to maintain and upgrade shopfloor skill.

Hyer and Wemmerlov (1984), surveying the American engineering scene, found that new technology offered opportunities to create better jobs for those at the lower levels of organisations. Cross (1983), in Britain, noted that micro-electronics required shopfloor workers to develop new and wider skills. Ouellette et al (1983) have observed that shopfloor automation can cut out boring, monotonous and dangerous jobs. From a trade union perspective, a Labour Research Department (1982) survey found no evidence of a deskilling tendency with new technology; instead, they found it tended to bring increased responsibility for workers.

In terms of white collar jobs, Kassler (1981) has argued that computers have led to jobs with a higher level of skill than before. Cockburn (1983) has pointed out that the computerisation of printing opens up skill opportunities not previously open to clerical workers, especially women. Bird (1980) found that new technology created better, more highly skilled, office jobs.

Others have also concluded that new technology will lead to better jobs (Sell, 1984a; Tarling, n.d.; Walton, 1982).

<u>The case against technological determinism continued</u>: As can be seen, there is plenty of evidence to support both those who believe micro-electronics will create better jobs and those who believe it will create worse jobs. Nor is it the case that these contradictory views arise because researchers are looking at different applications of new technology. A look at what has been written about word processors, for example, confirms this.

Bird (1980) found that 75% of the word processor operators she surveyed reported that it had made their job more satisfying than before. Stonier (1980) also found this to be the case with word processor operators he studied. On the other hand, C Davis (1979) observed that boredom was a major problem for them, whilst Baxter (1979) argued that word processing led to deskilling.

A possible way of reconciling these differing reports of the effects of word processors, and maybe new technology in general, is put forward by Wall et al (1984). They point out that, within limits, choices exist with regard to how the word processor is used, and, dependent upon these choices, the resultant jobs can be good, bad or indifferent.

The issue of choice, and what factors influence the choices made, was also noted with regard to organisational structure.

As pointed out, a large number of writers have rejected a deterministic view of new technology. They have argued, both in terms of organisational structure and job design, that there are options as to how new technology is used, and that the actual choices that are made, whilst being influenced by it, are not determined solely by the technology (Buchanan, 1984; Cooley, 1980; Kemp et al, 1984; Land et al, 1983b).

Choice and New Technology

If it is the case that new technology is not deterministic, then it raises the question of what does determine the way the technology is used? A wide range of factors have been put forward by researchers as being important in determining the outcome of technical change.

Research by Buchanan (1984) and Buchanan and Boddy (1983) has demonstrated that in particular instances, it was management control objectives, especially by lower management, which determined the outcome of technical change. They also pointed out that the control objective pursued by one level of management could conflict with the objectives of other levels of management.

Francis et al (1982) have also found evidence that control of labour is a factor when introducing new technology. Perrow (1983) has taken this point one step further. He believes that not only do senior managers use technology to bolster their control of the organisation, but they also influence the design of the technology to this end as well. Cooley (1980 and 1983) and Noble (1979) have also suggested that management control objectives affect the design of technology.

Shaiken (1984) is another writer who sees management as deliberately choosing to use technology in such a way as to increase their control. White (1983) has also mentioned this as a factor which influences technical change.

Jones (1979) concluded that the outcome of technical change depended on the power, values and interests of those involved. Williams and Steward (1984), whilst pointing out the importance of control, also point out that technical change in Britain has to be understood within the context of the particular economic circumstances that companies in this country face with regard to the effects of the world recession.

Clegg et al (1984) have drawn attention to the particular organisational context within which change takes place as being important. They draw especial attention to managerial style and organisational structure. Gough and Stiller (1983) have pointed to the constraints on choice imposed by existing control and information structures, as well as the values held by those responsible for introducing new technology.

Likewise, Mumford (1981) has pointed to the importance of individual and organisational values. She has also (Mumford, 1979) drawn attention to a "powerful ideology" which grips Britain and other industrial countries: this is the belief that people are expendable, that they are an easily replaced commodity, and, therefore, they need not be taken into account when designing organisational systems or jobs.

Warner (1984), Hartman et al (1983), Sorge et al (1983) and Nicholas et al (1983) are a group of researchers who have studied the introduction of new technology within and between Great

Britain and West Germany. Their conclusions give societal differences an important role in shaping the variety of organisational arrangements that accompany the introduction of new technology in these countries.

They also stress the importance of company size, market and product in influencing choice. Dunn (1984) has suggested that size and structure are both important with regard to the introduction and use of technology.

Tarling (n.d.) is another who has pointed to product and product market as important. Littler (1983) has not only drawn attention to the importance of market pressures but also to historically specific managerial ideologies such as Scientific Management. Both Cooley (1980) and Rosenbrock (1981) have stressed the need to see present organisational, job design, and technological developments within their historical context, and especially, in the case of Britain, the importance of the Industrial Revolution in shaping the values and attitudes of managers and workers.

Whilst the above review of non-technological factors which influence change is by no means exhaustive, it is representative of the work in this area. From it, seven factors, other than the technology itself, emerge as being important in shaping the outcome of technical change within particular organisations.

The first factor is the power relations within the organisation. In many cases, the outcome of technical change is seen as a purely management-worker clash. Management are seen as using technology to gain greater control over the workforce. However, this issue also includes power battles between different sections of management and between different sections of the workforce.

The second factor is the organisation's existing structure and philosophy/culture. The structure is seen as important in restricting the options that are seen as possible by those in the organisation; whilst the organisation's philosophy/culture is seen as important in shaping the choices that individuals or groups pursue.

The third factor is the organisation's market and product. These are seen as influencing what is "best" for the organisation: different markets and products lead to different "best" solutions.

The fourth factor is the size of the organisation. In the literature, increasing size is associated with bureaucracy and the fragmentation of jobs.

The fifth factor is the values, attitudes and self-interest of the individuals involved. Regardless of the organisation's philosophy/culture, individuals' values, etc., are seen as important because they are the ones who have to take choices and live with the results of the choices made by themselves and others.

The sixth factor is societal differences. The structure of individual societies, their industry, economy and culture, are seen as important in shaping the pattern of organisational arrangements that apply in particular countries.

The last factor is historical developments both within and between countries. This relates to how particular economies develop, but also the development of ideologies which shape organisational and individual choices.

No one writer or group of writers seems to espouse all of these factors, but all of these are given in the literature as being important determinants of the outcome, for individuals and organisations, of technical change. These issues will be returned to in Chapter 4.

CONCLUSION

As can be seen, a number of overlapping, but not necessarily inter-linking, factors have been cited in the literature as being important in shaping the outcome of technological change. Superficially at least, they bear some relation to Contingency Theory (Child, 1984); however, in some very important instances, such as power relations, organisational philosophy and values, and individuals' values, they depart significantly from it.

The importance of developing a clear conceptual framework in order to understand the factors involved in successfully choosing and using new technology cannot be overstated. Only by understanding the factors which influence the change process can the outcome of that process be beneficial to individuals, organisations and society as a whole. At the moment, as Rosenbrock (1981), Cooley (1983) and Bessant (1983) have pointed out, Britain and other countries are at a historic turning point. The choices about technology and how it is to be used are relatively open, but, in a few years' time, fixed patterns will emerge, and these will shape the design of individual jobs, organisational structures, and even the type of societies we will live in for generations to come.

From the previous section, it becomes obvious that the development of a conceptual framework is dependent upon an understanding of the role played by non-technical factors in the process of technical change.

It will be demonstrated that the forces which influence contemporary practice with regard to work organisation and job design are products of, and cannot be understood without recourse to, their historical development. Therefore, Chapter 2 will examine the origins and development of work organisation and job design, and Chapter 3 will examine contemporary approaches to these issues.

Chapter 4 will link together these chapters, with Chapter 1, in order to present a conceptual framework for understanding the impact of technical change.

CHAPTER TWO

THE ORIGINS AND DEVELOPMENT OF WORK ORGANISATION AND JOB DESIGN

INTRODUCTION

This chapter is split into two parts. Part one examines the origins of modern work organisation and job design by looking at the emergence of the factory system in Britain's Industrial Revolution. It describes the role played in this by labour and technology, and argues that the factory system emerged for organisational reasons concerned with the control of labour rather than technological ones, and that technological developments were shaped by the needs of the factory system rather than the reverse.

Part two deals with the development of work organisation and job design in the 19th century. It is demonstrated that, from a trial and error basis, a pattern based on the division of labour and the fragmentation of skills does emerge. This pattern, arising out of a variety of organisational arrangements, develops through the 19th century and reaches its culmination as a concrete theory in the work of F W Taylor.

These developments are tempered by the opposition of labour, but this opposition also helps to fuel the dominant management ideology which emerges in this period and underpins Taylor's work. This is the view that labour is unreliable and would, if not controlled or eliminated, pose a serious threat to the main business objective of organisations: profitability.

PART ONE

THE ORIGINS OF WORK ORGANISATION AND JOB DESIGN

The Origins of the Factory System

The origins of the factory system lie in Britain's Industrial Revolution, and as Weber (1928) has pointed out, its distinguishing characteristic was ". . . *in general* . . . *not* the implements of work applied [i.e. the technology,] but the concentration of ownership of workplace, means of work, source of power and raw material in one and the same hand, that of the entrepreneur." (p 302).

Factories of sorts had existed in other countries before the Industrial Revolution, but these were few and tended to be staffed by slave labour. Those who were involved in industrial production were either independent artisans, members of guilds, or involved in it part-time as an agricultural by-occupation. In *none* of these instances was production *concentrated* under *one* roof nor were producers employed by someone else (Gorz, 1976). Therefore, the factory was something new and, at least in the early 19th century, synonymous with textile production.

Before, and during the early part of, the Industrial Revolution, textile production was based in the countryside where 80% of the population lived (Hobsbawm, 1968; Tillett, 1970). As Ashton (1948) has commented: "There was probably no county in England or Wales in which woollen cloth was not produced by the part-time work of peasants, farmers and agricultural labourers." However, as the 18th century progressed, the demand for textiles grew and some "men and women [became] specialist spinners or weavers, thinking first of wool, treating work on the land as, at most, a by-occupation." (p 23).

As demand for, and production of, textiles grew (particularly international demand), new mechanisms sprang up to link producer to consumer. The "putting-out" system became the standard mechanism. This was a system where a large merchant would "put out" work to an independent domestic producer. This arrangement had three advantages for the merchant: it was cheap - there were few overheads; it was flexible - production could easily be expanded or contracted as demand fluctuated; and it avoided the problems of directly employing a workforce (Gospel, 1981).

However, as demand further increased, this system became more elaborate and more costly. The merchant would himself employ putter-outs who themselves might employ an intermediary. In many cases, the putter-out came to supply raw materials and even the tools of production, looms, etc. (Ashton, 1948).

The point to note is that increased demand was not, initially at least, caused by the cheapening of the product due to technological change, but to the opening up of new markets and the multiplier effect this had on international trade.

> The discovery of America, the rounding of the Cape, opened up fresh grounds . . . The East-Indian and Chinese markets, the colonisation of America, trade with the colonies, the increase in the means of exchange and in commodities generally, gave to commerce, to navigation, to industry, an impulse never before known . . . (Marx and Engels, 1888, p80).

The move from handicraft production to putting-out sufficed the needs of the market for a time, but eventually, as the system grew, it became strained. The long chain of organisation which linked producer to consumer became ever more complex and difficult for the merchant to control. It was the merchant, developing new markets and finding new sources of production, who was the dominant and dynamic force in the system, and it was the merchant who wished to change the system. The incompatibility between the large and complex organisation of distribution and the "innumerable tiny domestic workshop units, unsupervised and unsupervisable" was bound to "set up tensions and drive the merchants to seek new ways of production", whereby they could impose "their own managerial . . . practices on the productive sector" (Pollard, 1965, p44).

Dishonesty was rife on both sides; merchants tried to cheat producers and producers retaliated. For the merchant there was also the problem of getting the producer to deliver the goods when required. The merchant increasingly used the law to impose his will on the producer. Acts of Parliament, with increasingly heavy penalties, were passed in 1703, 1740, 1749 and 1777. These were not just to stop dishonesty on the part of the producers, but also to impose strict delivery conditions (Ashton, 1948, p 44).

Nevertheless, the law could not overcome the basic incompatibility between producer and distributor. It was a clash of different economic and social systems which had different values. For the capitalist merchant, the expansion of markets was a chance to increase his profits. For the rural domestic producer, it merely created the conditions for increased leisure. As Marglin (1976) has put it: ". . . wages rose and workers insisted in taking out a portion of their gains in the form of greater leisure. However sensible this may have been from their own point of view, it is no way for an enterprising capitalist to get ahead" (p 35).

Some histories of the Industrial Revolution tend to dwell on technology as being the moving force towards centralisation of production (Ashton, 1948; Mathias, 1969). However, the evidence would tend to suggest other forces were also at work, notably the need of merchants to gain better control of the production process.

> . . . the agglomeration of workers into factories was a natural outgrowth of the putting-out system (a result, if you will, of its internal contradictions) whose success had little or nothing to do with the technological superiority of large-scale machinery. The key to the success of the factory, as well as its inspiration, was the substitution of capitalists' for workers' control of the production process; discipline and supervision could and did reduce costs without being technologically superior (Marglin, 1976, pp 28 - 29).

Ashton (1948) points to specific cases where:-

> . . . the reasons [for factory production] were economic rather than technological . . . it was the need for supervision of work which led Peter Stubbs to gather the scattered file makers into his works at Warrington. In the pottery trade, the economies to be made from the division and sub-division of labour were the chief inducements to the creation of Wedgwood's Etruria. (p88)

Therefore, the impetus for the creation of the factory system came from merchants who believed it would give them greater control of the production process. They would then be able to take full advantage of expanding markets and reap greater profits. However, whilst the advantages to be gained by centralising production under one roof were evident from the employers' side, it was equally evident that there were disadvantages from the employees' side.

Labour and the early factory system

The factory of the Industrial Revolution tends to be described as a place where free men and women sold, of their own volition, their labour power to an entrepreneur who would supply the other elements of production: machinery and raw materials (Ashton, 1948).

However, the reality was somewhat different, at least as far as the suppliers of labour were concerned. The fact is that labour was very reluctant to take up factory employment. The reasons for this were three-fold. The first was that it involved a wholesale change of culture, environment and way of life.

> The reasons for the "attractions of cottage industry", or rather the repulsion of factory industry, were many and varied . . . there was a whole new culture to be absorbed and an old one to be traduced and spurned, there were new surroundings, often in different parts of the country, new relations with employers and new uncertainties of livelihood, new friends and neighbours, new marriage patterns and behaviour patterns of children and adults within the family and without. (Pollard, 1965, p191).

This was especially the case in the weaving communities which had developed their own rich and distinct cultures.

> Every weaving district had its own weaver-poets, biologists, mathematicians, musicians, geologists, botanists . . . there are accounts of weavers in isolated villages who taught themselves geometry by chalking on the flagstones, and who were eager to discuss the differential calculus. (Thompson, 1968, p322).

The second was the harsh and unremitting discipline of the factory. The following quotations give some flavour of factory life:-

> . . . the worker was treated as a piece of mechanism, who obeys the simplest behaviourist stimulus and response rules, and whose other mental capacities and interests could be ignored. (Pollard, 1965, p243).
>
> In the handicrafts and manufacture, the workman makes use of a tool; in the factory, the machine makes use of him. (Marx, 1886, p422).

> The main difficulty [with the early factory system] . . . lay . . . above all in training human beings to renounce their desultory habits of work and to identify themselves with the unvarying regularity of the complex automaton [the factory]. (Ure, 1835, p15).

The penalties for "desultory habits" were swift and unpleasant. Beatings were common for child labour and even some adults. Fines were arbitrarily imposed and dismissal, with only the workhouse to fall back on, was the ultimate sanction (Pollard, 1965).

The final obstacle to enticing labour into factories was, as Pollard (1965) has pointed out, the "modelling of many works on workhouses or prisons, a fact well known to the working population" (p190). It was not just that the regime inside was fashioned on these establishments, but also that they supplied much of the labour for the early factories. Up to one-third of factory labour was pauper children hired out by the workhouses. Indeed, to complete the process, many workhouses turned themselves into factories in order to "see idle men punished and educated to work". It is hardly surprising, therefore, that the "association of factory labour with pauper compulsion was strong in many people's minds" (Pollard, 1965, pp 192 - 195).

Given the tradition of the peasant whose life was conditioned and given variety by the seasons, and the artisan, who controlled his own work, the rejection of the factory was quite natural.

Nevertheless, what took place in the Industrial Revolution was not just a clash between two systems of production: cottage and guild versus factory. It was also a clash between two economic systems which put different values on human labour. On the one hand was the agrarian, exchange, economy which was based on subsistence farming and craft production. It was a system where "most workers were free in some measure to determine their hours of work" (Ashton, 1948, p42), and where the:-

> . . . labourer responded to material incentives, insofar as he wanted to earn enough to enjoy what was thought of as comfort at the social level to which it had pleased god to call him . . . If he earned more than the pittance he regarded as sufficient, he might . . . take it out in leisure, in parties and alcohol. (Hobsbawm, 1968, p87).

On the other hand was the capitalist, money, economy where workers were treated like any other commodity: to be bought and used; where the needs of capital necessitated regular and stable workers, and where a "preference for leisure" by workers was seen as a "desultory habit" by employers - a habit which had to be overcome by harsh discipline (Gorz, 1976, pp 34 - 35).

Employers justified this harsh treatment of labour not only on economic grounds but also on moral grounds: "The discipline demanded by the factories was viewed, in the minds of owners and men of property, as a moral corrective for godless men". (Tillett, 1970, p36). Or, as one contemporary observer put it:-

> It is a fact well known . . . that scarcity, to a certain degree, promotes industry . . . We can fairly aver that a reduction of wages . . . would be a national blessing and advantage, and no real injury to the poor. By this means we might keep our trade, uphold our rents, and reform the people into the bargain. (Quoted in Thompson, 1968, p306).

Even the phraseology of the time leaves no doubt as to how employers saw their relationship with labour. Terms such as "the organisation and its members" or "employers and employees" were unknown; instead, phrases such as "masters and men" or "masters and servants" were used. When Parliament, in 1824, passed legislation to regulate the terms of contract between employers and employees, it was called "The Master and Servant Act" (Storey, 1983).

Given this situation, and given what modern theorists of job design have said about the importance of autonomy (Child, 1984), it comes as no shock that "workers were reluctant to enter factories because in doing so, men lost their birthright: independence." (Hobsbawm, 1968, p 68).

Nor should it come as a surprise that, on occasions, the resistance to the factory system turned into violence against people and property. The 19th century was marked by periodic eruptions of violence caused by the establishment of factories and the introduction of machines. For example, in the 1810s and 1820s, there were outbreaks of "Luddism"; and in 1830, agricultural labourers revolted against the introduction of farm machinery. Even as late as the 1860s, there were serious outbursts of violence when employers in the Sheffield cutlery industry and the Manchester construction industry began to introduce machinery. (Berg, 1979; Friedman, 1978; Thompson, 1968; Tillett, 1970).

It was not just potential factory workers who opposed the factory. Small businessmen and farmers also opposed it because they saw the new economic system as a threat to their way of life. Many went so far as to support and even instigate the bouts of machine-breaking that took place (Hobsbawm, 1968).

The factory system and the market economy were also opposed on moral grounds. The factories housed large numbers of young men and women, side by side, and could therefore, it was argued, lead to degeneracy; whilst the market economy undermined the age-old religious-based system of the "just price" and the "fair wage". (Pollard, 1965).

Despite the difficulties of recruiting and keeping labour and despite opposition from other quarters, the factory system flourished because it provided employers with better conditions for profitable production. Consequently, other sources of employment opportunities dwindled and so the supply of labour grew.

Much of the credit for the success of the factory system has been given to the role played by technology in increasing productivity; however, there is evidence to suggest that this overstates the importance of technology.

Technology and the Early Factory System

In describing the Industrial Revolution, historians often resort to the production of a list of inventions: Hargreaves' spinning jenny; Crompton's mule; Arkwright's water frame; Roberts' self-acting mule, etc. (Council for Science and Society, 1981; Mathias, 1969). By so doing, the impression is given that it was the appearance of new inventions which created the need for, shaped the form of, and developed the factory system. In fact, the reverse seems to have been the case in most instances; it was the needs of the factory system that created the demand for, and shaped the form of, technological development (Berg, 1979; Friedman, 1978; Marglin, 1976; Rosenbrock, 1982).

As argued in the previous sections of this chapter, the initial impetus to bringing workers together under one roof was not the appearance of "factory technology", but the merchants' need for better control over the supply and quality of the goods they were selling. Indeed, the earliest factories of the Industrial Revolution, if that is not too grand a word for them, were small, un-powered, weaving or spinning sheds which used existing technology. It is true that a few large factories, using water and later steam power, did quickly appear, but in the main, factories were small and not at all capital-intensive (Marglin, 1976; Thompson, 1968; Tillett, 1970). As Hobsbawm (1962) has pointed out, the technical basis of the cotton industry, the leading sector in the Industrial Revolution, was "exceedingly modest" (p 48).

In 1780, the investment in fixed equipment and stock was only £10 per factory worker. Even by 1830, when the factory system was well established, the figure was still under £100 per worker (including stock). Or, to put it in a wider context, the textile industry, which in 1830 employed 160,000 people, had fixed equipment and stock valued at only £15 million (Pollard, 1965).

Given this situation, it is hardly surprising that capital investment was quickly recovered and that it was running expenses, mainly wages and raw materials, which formed the bulk of a manufacturer's costs (Hobsbawm, 1968; Tillett, 1970). Consequently, it was the factory owner's ability to control the length of the working day and week, whilst keeping wages low, which caused the significant increases in overall productivity per worker that were seen under the factory system, rather than the adoption of water or steam power, or any other specific technical change. Indeed, throughout the 19th century, increases in output always required increases in labour (Thompson, 1983).

It was the need for a workforce which could be "persuaded" to work long hours for low wages that led factory owners to use child and female labour. At that time, women made up half the working population of the textile industry, because they provided a cheap supply of labour and were considered ". . . more reliable than adult males" (Tillett, 1970, p36). In fact, it has been argued that the plentiful supply of cheap labour that had become available to employers due to urban population growth and the fall in rural and agricultural job opportunities was an economic discouragement to the adoption of new inventions in Britain in the 19th century. The argument is that cheap labour costs make it difficult to justify, economically, the introduction of capital equipment (Habakkuk, 1962; Levine, 1967; Payne, 1974).

Certainly, it seems to be the case that employers in the 19th century concentrated on using machinery to replace labour that was expensive and/or in short supply. Whilst there were many unskilled workers at this time, there were also significant numbers of workers who possessed crucial skills and who used the fact to bargain for higher wages and a degree of freedom not given to those less skilled (Berg, 1979; Littler, 1982).

An example in the textile industry were the woolcombers. They gained a reputation, amongst employers, for lax time-keeping and insubordination. A contemporary observer remarked that:-

> They come on a Monday morning, and having lighted the fire in the comb pot, will frequently go away, and perhaps return no more till Wednesday or Thursday . . . (Quoted in Thompson, 1968, p311).

Not surprisingly, the disruption this type of behaviour caused to production, perhaps more so than the actual cost of wages, was greatly resented by employers, whose aim was to maximise production in order to maximise profits.

Certainly, Andrew Ure (1835), a propagandist for the factory system, saw it in this fashion. He urged employers to use technology to eliminate skilled workers, such as woolcombers, and to replace them with less skilled, more compliant, labour. Quoting the example of printers, he wrote:-

> In the spirit of Egyptian task-masters the operative printers dictated to the manufacturers the number and quality of the apprentices to be admitted into the trade, the hours of their own labour, and the wages to be paid them. At length capitalists sought deliverance from this intolerable bondage in the resources of science, and were speedily re-instated in their legitimate rule, that of the head over the inferior members . . . This . . . confirms the great doctrine . . . that when capital enlists science in her service, the refractory hand of labour will always be taught docility.
> (pp 368 - 369)

This view - that machinery would, and did, allow employers to reduce the need for, and increase control over, skilled labour - was held by many of Ure's contemporaries (Babbage, 1835; Colley and Thompson, 1867; Journeymen Bookbinders, 1831; Nasmyth, 1867 - 8; Taunton, 1867 - 8).

This point can be further illustrated by looking at the design of technology under the cottage system of production and under the factory system. Rosenbrock (1981 and 1982) has argued that, under the cottage system, new inventions had two characteristics:

they increased productivity and/or quality, and they maintained/ increased the skill of the producer. Under the factory system, he argues, new inventions and innovations still increase productivity and/or quality, but instead of maintaining or increasing skill, they actively reduce it by building skill into the technology in order to reduce the control labour has over the production process. He has illustrated this (Rosenbrock, 1982) by looking at Hargreaves' development of the spinning jenny for the cottage system, and Roberts' development of the self-acting mule for use in the factory. Hargreaves designed the spinning jenny for his own or his family's use, and it was therefore "natural for Hargreaves to envisage the machine as an aid to existing skill. It did not reject the skill of the spinner, but rather co-operated with it to make it more productive" (p1). In the case of the self-acting mule, "Roberts was an engineer inventing on behalf of the mill-owners, and none of these intended to work the machines themselves . . . Above all the mill-owners wished at all costs to eliminate skill. First, because it was expensive . . . Secondly, and more importantly, only the skilled in that day could strike" (p2). Ure (1836) commented that the principal benefit of Roberts' invention was ". . . a release from the domination which he [the spinner] had for so long a period exercised over his employer . . . " (p199).

It has been argued that, in the Industrial Revolution, the main contribution of technology was to replace muscle power with mechanical power (Ashton, 1948; Mathias, 1969). However, as can be seen, this was not always the case. In fact, in the 19th century, there were three overlapping phases of mechanisation, and in the second and third of these phases, the replacement of skill was more important than the replacement of muscle power.

The first phase was the linking of existing technology to water, and later steam, power. This did replace muscle power with machine power, and in some cases allowed children to take over the work previously done by adults, but, in the main, did not reduce skills (Thompson, 1968; Tillett, 1970). Indeed, in some cases, workers found their skills in greater demand than ever before, and it was this that sparked off the second phase of mechanisation.

This second phase saw the invention of new machines and improvement of existing ones. Roberts' self-acting mule is one example; there were many others in all industries. These inventions did reduce or eliminate the skill necessary to carry out production processes, thus facilitating the introduction of less skilled labour into previously skilled trades and crafts (Berg, 1979; Nasmyth, 1867-8; Swift, 1895).

However, the greater use of machinery which this brought about increased the demand for, and bargaining power of, the skilled workers who built the machines. This in turn created the conditions for the third phase of mechanisation.

This third phase saw the standardisation of the machines themselves through the use of interchangeable parts and more accurate production and measuring techniques. This not only reduced the cost of machinery, thus allowing it to be used on a wider scale, but also reduced the skills necessary to construct the machines (Hobsbawm, 1968; Levine, 1967; Tillett, 1970).

Thus it can be seen that technological change was not, in itself, the spur to the invention of the factory nor a stimulus to its continued development. Instead, the reverse was the case: the factory system, or rather the needs of those who controlled it, determined how, and in what areas, technology would be *developed* (Marglin, 1976).

The needs of factory owners were very simple: they wanted a compliant, low-cost workforce in order to take advantage of the growing demand for their goods, to allow them to maximise profits. Where skilled labour threatened the predictability of production and/or profits, then they would seek out methods to overcome this problem, technology being one of these methods.

However, more important than technology in reducing skill and in increasing output was the opportunity that the factory system offered for re-organising work and re-designing jobs.

PART TWO

THE DEVELOPMENT OF WORK ORGANISATION AND JOB DESIGN IN THE 19th CENTURY

The Beginnings

The key figure in the early factory system was the factory owner or "entrepreneur". As Flinn (1966) has pointed out:

> He it was who brought together the capital and the labour force, selected the most appropriate site for operations, chose the particular technologies of production to be employed, bargained for raw materials and found outlets for the finished product. (p79).

Most of these functions were not new; they had been carried out by merchants under the putting-out system. What was new was that workers were directly employed and organised under one roof (Pollard, 1965; Weber, 1928). Being a new development, there were no blueprints that could be used to guide the owner in his endeavours; both employers and employees had to invent the rules of the game as they went along. It was probably for this reason that most early factories were small - many employed no more than 10 or 12 people - and that they concentrated on one aspect of production, such as spinning, rather than attempting to bring the entire production process under one roof (Tillett, 1970). This meant that the early factory systems still had to rely either on the putting-out system or on other factories for key elements of production. Even in the textile industry, where the factory system began, there were still only 50% of textile workers employed in factories by 1830 (Hobsbawm, 1968).

Therefore, in the sense that he still had to co-ordinate external contractors, the early factory owner resembled the "putter-out" rather than the modern manager of today.

Nevertheless, owners had to devise methods for organising and controlling labour. In the beginning, these were quite simple. The objective was to ensure that workers arrived on time, did not leave early, and, in the opinion of the owner, worked hard whilst they were there. In the smaller establishments, the owner might supervise this process himself or, as firms got bigger, he might subcontract supervision out to someone else. Consequently, a wide variety of systems for organising work and controlling labour sprang up. It was not uncommon to have direct employees; subcontract supervisors who were paid in relation to the output of the workers they supervised; and skilled workers responsible to the owner for their production, but paid in relation to their output, all working side by side. Indeed, the direct employees, paid a fixed rate, might even employ their own helper. Therefore, in the beginning at least, the factory owner solved his labour management problems by both internal and external subcontraction, where to do so did not conflict with profitability (Clawson, 1980 a and b; Friedman, 1978; Storey, 1983; Tillett, 1970).

In his attitude towards labour, the factory owner shared the common prejudices of the day. Workers were seen as unreliable, only interested in money, and as considering work as a burden. For this reason, discipline, they believed, needed to be severe in order to make them work, but, if this task could be subcontracted out to somebody else without threatening profits, then so much the better (Davis and Taylor, 1979; Pollard, 1965).

In the early days of the factory, employers were more interested with increasing the hours of work in order to increase output than in the actual details of work carried out in the factory. However, this was not so in all factories. There were a few factories where production was on a large scale, and where employers paid detailed attention to the organisation of work and the production methods employed. Wedgwood's pottery works was one such example. He employed large numbers of people and had developed a system for organising production that split the process down into separate departments with specialist supervisors. Work was organised almost on a flow-line basis, and the skill involved in each operation had been sub-divided so as, in Wedgwood's words, "to make machines of men as cannot err" (quoted in Tillett, 1970, p 37). Boulton and Watt's engineering works, established in the 1770s, was another example where work was organised and jobs designed in such a way that the need for skilled labour was reduced; but even there, it was not possible to dispense with the services of highly skilled millwrights. Their factory was also unusual in that it kept detailed production records, a practice unknown in the vast majority of establishments (Roll, 1930).

Though examples of factory organisation such as these were rare, they were a pointer to the future and, importantly, became training grounds for the next generation of factory owners and managers (Ashton, 1948).

A Pattern Emerges

By the 1830s, Britain had a growing population of workers acclimatised to the factory system, who knew no other way of life. It also, more importantly, had a generation of owners who had not only grown up with the factory system, but were actively developing it. The smaller factories which employed 10 - 12 people were disappearing, and whilst large factories were still a rarity (there were only 7 textile mills that employed over 1,000 people in 1833, and only 23 that employed over 500), the average size of factories was increasing; in 1838, it was 137 employees (Hobsbawm, 1968; Tillett, 1970). Therefore, almost for the first time, common management problems were beginning to emerge and be discussed. Trial and error was still probably the most common method of solving problems, but the methods used by innovative factory owners, such as Wedgwood, Boulton and Watt, etc., were being written about and gaining adherents (Berg, 1979).

Slowly, a pattern of work organisation and job design was emerging. It was based on the principle of the division of labour, which had been popularised by Adam Smith in his book "The Wealth of Nations" published in 1776 (Smith, 1776).

Smith used the now famous example of pin-making to illustrate what he saw as the advantages of the division of labour. He pointed out that a pin could be made entirely by one person doing everything, or by a number of different people each specialising in one aspect of its production. He believed the latter was more efficient and productive, for three reasons:

i) A workman who constantly performs one simple task will quickly acquire greater dexterity than one who performs a variety of tasks;

ii) It avoids the loss of time necessitated by one person moving from one task to another;

iii) The concentration of attention on one special task leads to the invention of machines which aid the productivity of labour and allow one person to do the work previously performed by many.

More and more, in accordance with Smith's advice, production was split up into smaller elements and skills were fragmented (Berg, 1979; Thompson, 1983; Tillett, 1970).

Highly skilled occupations such as that of the millwright disappeared. What one man previously did alone might be done by 2, 3 or 20 different, and less skilled, workers. This process was aided by technical developments, such as the lathe slide-rest which reduced the skill involved in turning, but it was not driven by them; rather the reverse (Rosenbrock, 1981; Swift, 1895).

One of the key theorists and propagandists of these developments was Charles Babbage, who, in 1835, published his famous book "On the Economy of Machinery and Manufactures". Drawing on the writings of Adam Smith, and anticipating the later work of Frederick Taylor, he showed how the division of labour could be applied to the microscopic analysis of workshop behaviour. He emphasised the advantages, to employers, of dividing tasks between and within mental and manual labour. He envisaged three "classes" involved in the production process: the entrepreneur and his technical aides would design the machinery; operative engineers would execute their plans, based on a partial knowledge of the processes; and the mass of workers, with a lower level of skill, would be employed in using the machines. This, in Babbage's view (1835), would reduce the cost of labour:-

> . . . the master manufacturer, by dividing the work to be executed into different processes, each requiring different degrees of skill or force, can purchase exactly the precise quality of both which is necessary for each process . . . (pvii)

Babbage also advocated the use of bonus systems to encourage productivity, and the keeping of accurate production records so that, amongst other things, the level of output from each worker could be recorded.

Another influential writer was Andrew Ure, who pointed to the role that technology could play in cheapening and controlling labour:-

> By developing machines . . . which require only unskilled instead of skilled labour, the cost of labour can be reduced [and] the bargaining position of the worker can be weakened. (Ure, 1836, pp viii - ix)

The next 40 years saw the diffusion of these ideas into many factories. This process was aided by the further growth of the factory system: 50% of the population worked in factories by 1871; and by the increase in factory size - by 1870, the average factory employed 181 people (Storey, 1983; Tillett, 1970).

One reason for the growth in factory size was the increase in demand for manufactured goods; another was the trend towards the integration of production under one roof. For a variety of reasons, problems with outside contractors, costs, and, perhaps, a growing confidence in their own managerial abilities, factory owners wanted more direct control over all aspects of production (Thompson, 1983).

For workers, the growth of factory size posed a double threat. On the one hand, it made it easier for employers to fragment tasks and skills; on the other hand, the increase in size meant an increase in overheads, more administration, more supervisors, more machines, which could only be justified by a reduction in production costs - which in the final analysis meant either lower wages, higher productivity per worker, or both.

Therefore, factory owners began increasingly to examine the details of work, the norms of production, the utilisation of plant and machinery, which in turn led to an increased division of labour and reduction in skills (Berg, 1979; Tillett, 1970).

However, these changes met both political and industrial opposition from labour. Politically, the period 1830 - 1870 saw the rise and decline of Chartism, the widening of the Parliamentary franchise, and legislation regarding safety in factories and regulating the hours of work of children. There were increasing demands for a shorter working week for adults, a 10-hour day, and even for machines to be taxed in order to discourage their use by employers. All these developments reflected the rising importance of the industrial working class (Hobsbawm, 1968; Pollard, 1965).

Amongst industrial workers, this period saw the emergence of craft unions which were established to defend the status and wages of skilled, male, workers. These unions, especially in the textile and engineering industries, used two main tactics to achieve their aims. The first was to restrict entry to the craft or trade by making it dependent on a long, union-controlled, apprenticeship, and by limiting the number of apprentices in any one establishment. This, where it was effective, meant that the supply of labour was kept at a level that would maintain the union in an advantageous bargaining position. The other main tactic employed was to resist employers' demands for changes in work organisation or methods which would either reduce or eliminate their members' skill and/or control over the work process. This included resisting attempts to put boys on machines instead of skilled men, refusing to work more than one machine at a time, and bitterly opposing attempts to remove traditional areas of discretion from them, such as the determining of the pace and quality of work, and giving this responsibility to supervisors.

The result of these tactics for workers was double-edged. On the one hand, the efforts of factory owners to reduce the skill and control of workers were, to an extent which varied from factory to factory and industry to industry, thwarted. On the other hand, the formation of strong craft unions acted as an incentive to employers to intensify the process of undermining workers' status and skill (Berg, 1979; Friedman, 1978; Littler, 1982; Nasmyth, 1867-8; Penn, 1982; Thompson, 1983).

Therefore, as can be seen, as the factory system developed, and especially as factories grew in size, the problem of labour control grew in importance. Factory owners responded to the problem in a variety of ways, but increasingly they turned to the division of labour and the use of machines to control and deskill workers. This in turn brought an adverse reaction from skilled workers who began to organise in craft unions to resist employers' attacks on their skills and bargaining strength.

The Division of Labour Accelerates

The onset of the Great Depression in the 1870s reduced company profits, which in turn forced factory owners to take a greater interest in production costs and methods. The subsequent economic recovery in the 1890s also saw increased interest by owners in, and control over, the details of production. Therefore, this period saw an acceleration of the organisational trends that had been developing over the previous 50 years.

The late nineteenth and early twentieth century saw a "Merger Boom" brought about by the need to reduce competition. This was one of the reasons why the average size of factories increased by 50% between 1880 and 1919. Another reason was the fact that companies were continuing to reduce their reliance on outside subcontractors, and integrating production under one roof in order to cut costs (Allen, 1970; Levine, 1967; Payne, 1974; Tillett, 1970).

The growth in size caused organisational and control problems for management, which in turn led to the development of new management specialisms. This period saw, really for the first time, the emergence of a distinct managerial class as averse to the traditional owner-managers. Within companies, in order to cope with the problems of size, there was a growing separation of management functions. Firstly there was a separation between those involved in strategic, long-term, decision-making, and those involved in day-to-day decision-making. Then these functions themselves began to be divided. On the strategic side, such specialisms as planning, marketing, finance, etc., appeared;

and on the production side, managers began to seek specialist assistance from accountants, progress-chasers, rate-fixers and professional engineers charged with examining and cheapening production methods. The internal contractor disappeared in most industries and new, specialist, supervisors were given responsibility for functions previously carried out by many workers themselves, such as checking quality, determining the pace of work, and selecting the most appropriate tooling and methods (Clawson, 1980 A and B; Edwards, 1983; Locke, 1982; Storey, 1983; Williamson, 1973).

This explosion of managerial functions was accompanied and aided by the growth of publications dealing specifically with the analysis of management problems (Tillett, 1970).

Not surprisingly, there was also an increased acceleration in the division of labour on the factory floor. The production and ancillary processes were broken down into a greater number of separate departments. Within departments, work roles became narrower and the decision-making latitude of individual workers became more constrained. New incentive schemes were introduced to relate pay to production, and production quotas came to be determined more by management, through forms of work study, than through the imposition of "traditional" output norms by skilled workers. These changes were facilitated by developments in technology; a move to standardise products; and tighter quality specifications. However, this process would not have been possible without the information on production methods and times that was being collected, recorded, and used by the new management specialists involved in work study (Storey, 1983; Thompson, 1983).

Indeed, the paradox that faced this new managerial group, or groups as they quickly became, was that only by reducing the skills, wages, and status of other employees could they justify and increase their own status and remuneration (Locke, 1982; Tillett, 1970).

To the economic pressures on owners and managers to rationalise production was added, in the 1890s and 1900s, a growing public concern, almost hysteria, about the performance of British industry. As one British industry after another was overtaken by its German or American competitors, so the British public, or at least that section of it that read the "respectable" press, came to ask, to demand, "why?"

The answer that became accepted was that the British workman (or woman) was workshy in comparison with his foreign counterpart. The specific allegation was that they practised "go-slow" methods in order to restrict output and maintain wages/employment levels.

How widespread, or important, this practice was, no one could quantify; though it is hardly surprising, as work became, for many, denuded of intrinsic value and related purely to money, that workers should betray a more instrumental attitude towards their work. Nevertheless, whatever the rights and wrongs of the situation, it acted as an extra incentive for managers and owners to develop methods to extract more work from labour (Davis and Taylor, 1979; Levine, 1967; Thompson, 1983).

However, management did not have it all their own way. This period also saw a growth in, and widening of, trade union membership and militancy. Not only were craft unions recruiting more members, but also, from the 1880s, new unions were emerging to cater for the needs of semi- and unskilled workers of both sexes. The late 1890s and 1900s saw an increasing number of industrial disputes, many related to issues of pay, but others, such as the "Engineers' Lockout" of 1897/8, were concerned more with changes in the organisation of production (Hobsbawm, 1979; Pelling, 1976).

Therefore, whilst the 19th century saw the development of factory organisation, it also saw the development of organised resistance by labour.

Yet, from a managerial perspective, the changes in British industry, whilst being significant in terms of previous practice, were modest in comparison with what had taken place in America in the last few decades of the 19th century. This was a fact that the British public, as well as British managers, were well aware of. In international terms, British companies were too small, too conservative in work organisation and technology, and under-capitalised. Many of the organisational innovations and managerial developments were only feasible in large organisations, as were the technological developments. In Britain, the tendency was still for firms to be owned by one family or a small group of partners, and it was the case, in most instances, that the capital needed to foster growth was not available without outside investment. Faced with the choice between retaining control and remaining small, or losing control and expanding, owners chose the former (Allen, 1970; Levine, 1967; Payne, 1974).

Equally important was the fact that no theory existed that linked all the separate piecemeal organisational developments together in one set of guidelines for managers to use in re-organising work and jobs. However, developments in America were to remedy this situation.

The Origins of Scientific Management

America, up to 1860, had been an agricultural economy which lagged well behind Britain in terms of industrial production. However, from 1860 onwards, this changed rapidly, and by 1918, America had become the world's premier industrial nation (Rose, 1981; Zinn, 1980).

The scale of industries and the size of individual organisations was far greater than anything that existed in Britain at that time. Whereas the typical organisation in Britain was the small family-owned business, in America it was the monopoly, which dominated an entire industry, or the corporation which would have substantial holdings in a range of industries. Unlike Britain, the banks played a substantial part in merging together companies and linking together industries into giant industrial combines. Whislt individuals, such as J D Rockefeller, who acquired a personal fortune of two billion dollars, could and did own entire industries, the norm was for corporations to be owned by stockholders and run by professional managers who, whilst they might have shares in the corporation, did not own it. The evolution of the giant US Steel Corporation, which employed 200,000 people, is a case in point. Carnegie sold his steel company in 1900 for 419 million dollars. The company was then amalgamated with others to form US Steel, whereupon it was sold to shareholders for 1.3 billion dollars.

This was at a time when the British steel industry consisted of 100 blast furnaces owned by 95 separate companies.

The number of people employed in American manufacturing industry grew rapidly: in 1880, it was 3.21 millions, and by 1910, it had nearly tripled to 8.99 millions. Not unnaturally, given the structure of American industry, much of this growth was in white collar and administrative staff. As an example, there were 19,000 women office workers in 1870; by 1900, there were 500,000 (Levine, 1967; Zinn, 1980).

As can be imagined, given the organisational problems caused by the relatively modest growth in size of British organisations, American companies faced enormous organisational problems. These problems were made all the more severe by the rapidity of the rise of American industry. One of the main organisational concerns in America, as with Britain, was labour: its cost, its efficiency and its militancy. The period from 1860 to the First World War saw many bitter and violent clashes between employers and workers. The period also saw growing demands from trade unions and political groups for collective ownership of production, demands which employers treated as serious threats to their existence. Therefore, relations between employees and employers were, at this period, very hostile (Locke, 1982; Rose, 1981; Zinn, 1980).

In terms of the efficiency of labour, the frequently-voiced concerns of American industrialists sound remarkably like those of their British counterparts. They believed that workers consistently underperformed - that they collectively and individually restricted production to a level below what it should be (Locke, 1982; Tillett, 1970).

Another publicly-aired worry concerned the cost of labour. The demand for labour at this time, despite the continuous waves of immigration, outstripped the supply, and American employers believed that this led to higher wages than was the norm in Europe (Levine, 1967; Tillett, 1970).

Therefore, for a range of reasons, the concern with, and innovations in, work organisation and job design in America were more advanced than in Britain.

The 1880s and 1890s saw a number of well-thought-out and well-publicised attempts at work organisation in America. These were designed to increase production by the re-organisation of work, and to reduce workers' bargaining power by reducing the skill and discretion needed to carry out tasks. Most involved elaborate work study and recording methods as well as individual incentive schemes. There was also a greater standardisation of products and production methods than was common in Britain. The use of labour-saving, and deskilling, technology was also more advanced in America than Britain. This reflected labour costs, labour control problems, and the larger production runs in America (Levine, 1967; Tillett, 1970).

Given this situation, it is not surprising that there was a greater demand by American employers for a system of work organisation and job design which pulled together the various piecemeal developments into a coherent whole. In the 1900s, such a system emerged. Its originator, F W Taylor, termed it "Scientific Management", but it rapidly gained the alternative name of "Taylorism" (Locke, 1982). A detailed description of Scientific Management and its subsequent developments will be given in Chapter Three.

CONCLUSION

The important point to note about Scientific Management is the ideology which underpinned it. It was an ideology whose seeds were present at the birth of the factory system, but which came into its own as the profit motive developed.

The key to understanding the ideology is to recognise, as Drucker (1955) has put it, that the primary responsibility of management is to make a profit. This was the measure of managerial and organisational success and survival then as it is now. However, in order to achieve this, they had to produce goods, and the key to that process was labour. Therefore, profitability and the control of labour came to be seen as synonymous. It was the problems caused by the lack of control over labour that led the putter-outs to start to employ labour directly, thereby creating the factory system. This gave rise to more problems for employers; firstly, the problem of getting people into the factories, and secondly, getting them to work productively and cheaply once they were there. This was the paradox that labour posed for employers: it was an indispensable factor in creating profit, but its very indispensability was a threat to that profit. This led employers in Britain to adopt harsh devices to "encourage" labour to work. This was not because they were vicious men, though some obviously were, but because, in their ignorance, they knew no other way to achieve their aim of profit. They did not seek control for control's sake; indeed, they were quite happy to gain compliance by other methods, or to subcontract the responsibility to others, if profitability was not put at risk. However, as the 19th century proceeded, employers increasingly took on the responsibility of directly controlling labour and in so doing developed less harsh methods for gaining workers' co-operation. The culmination of that process was Scientific Management.

The employers' ideology that emerged from the 19th century and which underpinned Scientific Management was that in order to make profits, it was necessary to have the strictest control over what workers did, that the skill involved in individual jobs should be kept to a minimum, and that financial incentive was the only way to make people work.

Therefore, the culmination of over a century of the factory system was an ideology that saw the main component of the system, the worker, as a necessary evil whose input had to be kept to a minimum.

As will be described in the next two chapters and in the case studies, this ideology still dominates a great deal of the practice of work organisation and job design.

CHAPTER THREE

THE THEORY AND PRACTICE OF WORK ORGANISATION AND JOB DESIGN IN THE TWENTIETH CENTURY

This chapter will examine four major approaches to work organisation and job design which have emerged in the 20th century, and which inform the current debate on these issues. These are, in chronological order:- Scientific Management, Job Design, Contingency Theory and Labour Process theory. The first and last of these have their roots in the 19th century, whilst Job Design and Contingency Theory are products of post-1945 social and economic changes.

Scientific Management is the key reference point for the other three approaches. It was developed by Frederick Taylor in America at the turn of the century, and its core elements are the creation of jobs with low levels of skill and discretion, coupled with the belief that monetary incentives and strict managerial control are the only way to motivate workers.

Job Design is both a rejection of, and reaction against, Scientific Management. It argues that boring and monotonous jobs with little worker discretion are counter-productive to both individual and organisational well-being. Job Design theorists advocate creating jobs which demand skill and the ability to exercise discretion from the worker. Jobs of this kind would be intrinsically motivating and lead to both higher worker and organisational performance.

Contingency Theory is again a reaction against the "one best way" method advocated by Taylor. This theory argues that organisational structure and performance are dependent upon certain contingent variables which organisations face. These are environment, technology and size. Organisations maximise their performance by securing the appropriate fit between their structure and the contingencies they face. Therefore, whilst there is no "one best way" for all organisations, individual organisations do have only one choice if they are to maximise performance.

Labour Process theory is a Marxist approach to the analysis of job design and work organisation. This argues that the survival of capitalist enterprises is dependent upon their ability to exploit their workers. It sees this being achieved by the use of a combination of Scientific Management and technology to deskill and control workers.

The Chapter examines the contribution of these approaches and their shortcomings in order better to understand the factors influencing how organisations cope with change. It concludes by arguing that a range of factors from managerial values and beliefs to the prevailing social and economic climate are important in determining work organisation and job design within organisations, and that these will also influence the way that new technology is used.

SCIENTIFIC MANAGEMENT

Scientific Management, or Taylorism, to give it its popular title, was the "invention" of an American engineer, F W Taylor. It is, both in its theory and its practice, a highly controversial subject. For some, Taylor was a genius, whilst for others, he was an anti-trade union autocrat whose ideas were both barbaric and foolish (Locke, 1982; Pignon and Querzola, 1976; Rose, 1981).

His work has been praised both for its originality and its enduring relevance as a managerial philosophy (Boddewyn, 1961; Drucker, 1976); on the other hand, there are those who deny both its originality and its relevance to modern managerial problems (Rose, 1981; Tillett, 1970). For some, Taylor's ideas had relevance only for the period in which they emerged. Others argue that there are universal elements in Scientific Management which inform and influence current managerial ideas and practice and which have made Taylorism the dominant managerial philosophy of the 20th century (Kelly, 1978; Littler, 1978; Thompson, 1983).

Any examination of Scientific Management must begin with the period and circumstances in which it emerged. Taylor first began to promote his theory in turn-of-the-century America. America was in this period a rapidly-industrialising society; its economy was becoming dominated by very large industrial and commercial organisations. Such was the speed of economic growth that the demand for labour far outstripped the ability of the indigenous population to meet it, and this demand was therefore met by successive waves of immigrants who, in the main, had no previous industrial experience. America, at this time, was above all a rapidly-changing society with few stable features. Not surprisingly, these circumstances threw up tremendous social problems, not least of which was the issue of managerial authority.

Management-labour conflict was widespread; violence was not uncommon, and there was a growth of groups who challenged existing property rights and called for the collective ownership of property through the overthrow of capitalism.

The dominant managerial ideology of the period was Social-Darwinism, the survival of the fittest. Not only did this stress that the pursuit of individual wealth and success was the natural order of things, but that success in itself, no matter how achieved, bestowed on those who attained it authority over those who had not. Out of this developed a view that working men and women were somewhat wayward and unreliable machines who could be motivated only by money and controlled only by severe discipline. Partly for this latter reason, the division of labour was seen as being the most effective form of work organisation.

It was in this confused and antagonistic environment, with management seeking to legitimate its authority and workers challenging it, that Scientific Management emerged (Cherns, 1982; Locke, 1982; Rose, 1981; Tillett, 1970; Zinn, 1980).

Taylor started out in life as a pattern maker/machinist, though he had been expected to follow his father into the legal profession. He quickly became a machine shop foreman, which was a position that allowed the incumbent a great deal of autonomy at this time. As a machinist, he had developed the view that his fellow workers deliberately under-produced, which he called "soldiering" - the practice of doing very little whilst appearing to be busy. When he became a foreman, he declared that his aim was to increase productivity to the level that he believed it should be. Indeed, for the rest of his life, he was obsessed with the notion of eradicating "soldiering" and increasing productivity. His methods were harsh; he unilaterally cut piecework rates, increased speeds and feeds, changed methods and sacked people in order to achieve his aims.

Not surprisingly, this led him into intense conflict with those below him and even had an adverse effect on his own health.

The experience of his first attempt to re-organise work in order to increase productivity led him to review his ideas. He believed that for any new system of job design and work organisation to be accepted and to work, it must meet three criteria.

The first was that it should be systematic. He argued that arbitrary and inconsistent changes in working arrangements would not only meet opposition from workers but, because of their inconsistency, would fail to achieve the increases in productivity that he believed were possible.

The second criterion was that any system must be seen to be fair and objective by both workers and management; that it should be seen to be "scientific". He believed that existing systems of work measurement and organisation were based on guesswork, and for this reason were opposed and rejected by workers.

Thirdly, it should enhance and legitimate managerial authority and control. He argued that until workers accepted that managers had complete authority to organise the production system, then change would be resisted by workers. He believed that this acceptance would be achieved by developing a scientific approach to work and by demonstrating that only management were capable of prescribing the best work methods (Cherns, 1982; Council for Science and Society, 1981; Locke, 1982; Rose, 1981; Taylor, 1911 a and b).

He believed that a system based on these criteria would be to the mutual benefit of both workers and management because increased productivity would lead to both increased pay and increased profit. He shared the then common view that money was the only way to motivate people.

Over a period of some 20 years, in which he gained an international reputation for his innovations in cutting tool technology, he experimented with various systems of work organisation and analysis, before, in the 1900s, he launched Scientific Management. What emerged was a set of guidelines for the systematic analysis, specification and control of workers' jobs by management.

Scientific Management consists of three core elements: the systematic collection of knowledge about the work process by managers; the removal/reduction of discretion/control allowed to workers; and the laying down of standard procedures and times for carrying out particular tasks (Braverman, 1974; Gorz, 1976).

> The managers assume . . . the burden of gathering together all of the traditional knowledge which in the past has been possessed by the workman and then of classifying, tabulating and reducing this knowledge to rules, laws and formulae . . . (Taylor, 1911b, p 36).

This lays the groundwork for increased control. As long as workers possess a monopoly of knowledge about the work process, increased control is impossible. But once the knowledge is also possessed by managers, it becomes possible not only to establish what workers actually do with their time, but also by "reducing this knowledge to rules, laws and formulae", to decrease the knowledge that workers need to carry out a given task. It also, importantly, paves the way for the division of labour.

The next stage is that "All possible brain work should be removed from the shop and centred in the planning . . . department . . ." (Taylor, 1911a, pp 98-9). The divorce of conception from execution removes control from the worker, who no longer has discretion as to how tasks are carried out, and creates the conditions for the last element of Taylorism.

> Perhaps the most prominent single element in modern scientific management is the task idea. The work of every workman is fully planned out by management . . . and each man receives in most cases complete written instructions, describing in detail the task which he is to accomplish, as well as the means to be used in doing the work. This task specifies not only what is to be done but how it is to be done and the exact time allowed for doing it. (Taylor, 1911b, p 39).

This completes the process of gaining control over workers by managers. The workers become "human machines", told what to do, when to do it and how long to take. But, more than this, it allows new work organisation to be developed and new work processes and equipment to be introduced, and so workers move from having a monopoly of knowledge and control over their work to a position where the knowledge they have of the work process is minimal and their control is vastly reduced. The result is not only a reduction in the skills required and the wages paid, but also the creation of jobs which are so narrow and tightly-specified that the period needed to train someone to do them is greatly reduced. This removes the last bargaining counter of labour: scarcity of skill (Braverman, 1974; Kelly, 1982a; Littler, 1978; Pignon and Querzola, 1976).

Scientific Management was not, despite Taylor's undoubted talents as a self-publicist, an overnight success with either workers or managers. It met with opposition at home and was ignored abroad (Levine, 1967; Rose, 1981; Tillett, 1970).

Nevertheless, during, and especially after, the First World War, the precepts of Taylorism did begin to become widely adopted, firstly in America and later in Europe (Littler, 1978 and 1982; Wren, 1979). In America it was taken up by the new breed of professional engineer whose job it was to reduce production costs by examining and improving production methods. Scientific Management appealed to them for two reasons. Firstly, Taylorism, with its emphasis on "science" and the legitimation of managerial authority, was seen by this group, who grew from 7,000 in 1880 to 120,000 in 1920, as a system that would enhance their professional status. Secondly, its emphasis on work measurement, task reformulation and specification, and centralised control, was seen as a blueprint for how professional engineers should approach their work (Benson and Lloyd, 1983; Tillett, 1970).

Whilst many question the benefit and relevance of Scientific Management, few would deny that it has had a major impact on managerial thinking and practice in the 20th century. Indeed, from the 1950s onwards, a series of studies have emerged which show that Tayloristic principles underlie much of current job design and work organisation theory and practice (Clegg, 1984;

Davis and Canter, 1955; Davis et al, 1955; Hedberg and Mumford, 1975; Locke, 1982; Thompson, 1983).

Nevertheless, as Tillett (1970) points out, it would be a mistake to overestimate the originality of Taylor's work. His work drew together in one theory many of the practices and beliefs that had (as described in Chapter 2) become common currency in the 19th century: the recalcitrance of labour; the belief in motivation by money; the analysis of work; the fragmentation of jobs, especially the division of physical and mental tasks; and the rigid control over workers' activities.

Seen in this light, it is not surprising that Scientific Management became widely accepted and used, as it built on, and appealed to, deeply-held beliefs regarding the behaviour and motivation of workers. Perhaps Taylor's greatest achievement was that he brought these disparate beliefs and practices together in such a way as to provide both a formula for job design and work organisation and a legitimation of managers' authority over workers (Council for Science and Society, 1981; Rosenbrock, 1981; Tillett, 1970).

However, the fact that Scientific Management has become so institutionalised as a managerial philosophy has not protected it from serious criticism; rather the reverse. There are six main criticisms of it, ranging from attacks on its efficacy to moral objections, which are as follows:-

i) That Taylorism's preoccupation with narrow, tightly-controlled, fragmented jobs is counter-productive in terms of worker motivation and performance. The argument is that workers are alienated by such meaningless jobs and not only cease to give any more than the minimum effort that is forced from them, but also actively seek ways to restrict productivity. Therefore, rather than increasing the efficiency of the production process, Taylorism is seen as achieving the reverse (Buchanan, 1984; Clegg and Dunkerley, 1980; Council for Science and Society, 1981; Davis et al, 1955; Friedman, 1978; Johnson, 1968; Slater, 1968).

ii) That, following on from (i), Taylorism can have an adverse effect on total costs by increasing labour turnover and absenteeism, and reducing flexibility and product quality (Council for Science and Society, 1981; L E Davis, 1979; Storey, 1983).

iii) That the separation of planning from execution, and the consequent creation of numerous specialist management functions, leads to a plethora of separate departments, all pursuing different, though theoretically complementary, objectives. This is seen as being counter-productive, in that it leads to friction between different functions rather than the co-operation that is essential to efficient production (Bell, 1983; Hutton and Lawrence, 1979 and 1982).

iv) That Taylorism reinforces the belief of managers that workers need to be tightly controlled and only respond to financial incentives. Workers react to these restrictive conditions by being "recalcitrant" and by maximising the only satisfaction that is open to them: money. Thus, a vicious circle is created whereby fragmented and tightly-controlled jobs lead to alienation, and the management response to alienation is increased fragmentation and control. In such a situation, it becomes almost impossible, without major changes in managerial personnel, to reverse this state of affairs by creating better, more intrinsically motivating, jobs (Clegg and Dunkerley, 1980; L E Davis, 1979; Friedman, 1978; Mumford, 1979).

v) That Scientific Management is not really "scientific" at all, and that the supposed objective and systematic analysis and design of jobs is merely a cover behind which managers pursue control objectives (Grant, 1983; Gorz, 1976; Pignon and Querzola, 1976; Rose, 1981; Thompson, 1983).

vi) That there are alternatives to Taylorism, i.e. Job Design, which create better, more fulfilling, jobs, and which bring overall cost benefits, without any loss of individual productivity; and, therefore, managers are morally obliged to reject Scientific Management in favour of such alternatives (L E Davis, 1979; Mumford, 1979).

JOB DESIGN

In the last twenty to thirty years, Job Design, or work humanisation as it is less familiarly called, has come to challenge Scientific Management's dominance in the theory, though by no means the practice, of how jobs and work should be designed and organised.

Strangely enough, even while Scientific Management was still struggling to become established, the seeds of Job Design were being sown. Its origins can be traced back to studies in Britain during World War One on fatigue amongst women munitions workers, and work carried out in America at the same time on employee testing and selection. This work was further developed in the 1920s by Myers in Britain and Mayo in the United States. It was out of the latter's work with the Western Electric Company, the famous "Hawthorne experiments", that a new, non-economic explanation of workers' behaviour emerged and the Human Relations school was established. This school of thought rejected Taylor's model of "rational-economic man" in favour of "emotional man". The theory states that man needs more than just money from his work; that man has emotional needs which he seeks to fulfil.

The Western Electric studies also revealed that within the formal rules and structure of the organisation laid down by management, workers created their own "informal" rules and structures. Taylor had also noticed similar tendencies with regard to output norms, but whilst he believed these could and should be eradicated by better and tighter control of what workers do, the Hawthorne experiments contradicted this view. It emerged that workers constructed their own rules and norms not because management control was too lax, but as an attempt to create a sense of identity for themselves in what they saw as a hostile environment. This not only drew attention to the issue of whether too much control of work could be counter-productive, but also whether or not it was possible to control all aspects of work in any case. The Human Relations school advocated better communication between management and workers, and highlighted the crucial role played by supervisors in motivating and involving the workforce. They also drew attention to the need to see organisations as social systems composed of groups of workers; this view reflected in part the emergence of collectivist ideas, as opposed to Social-Darwinism, in America in the 1930s (Cherns, 1981; Katz, 1973; Mayo, 1938; Rose, 1981; Wilkinson, 1981).

These theoretical developments away from Taylorism were further strengthened by Maslow (1943) who suggested that human behaviour was driven by sets of needs or motivations. These form a "hierarchy of needs", ranging from physiological needs, through safety, love, esteem, and finally to self-actualisation; as one level of need is satisfied, so man pursues the next.

It was in the 1950s that Davis and Canter (1955), influenced by these theoretical developments, questioned the Tayloristic basis of job design and work organisation. They suggested that it would be possible to design jobs which would better satisfy not only human needs, but also organisational needs, in that as individual workers' satisfaction increased, so would their productivity.

Since then, many other writers have also contributed to the development and consolidation of Job Design theory (Davis et al, 1955; Guest, 1957; Hackman and Oldham, 1980; Herzberg, 1968; Likert, 1961; McGregor, 1967; Trist et al, 1963).

Job Design theory is a direct attack on the precepts of job design and work organisation that were embodied within Scientific Management. Whereas the tradition with Taylorism was to fit people to rigidly-defined and controlled jobs, Job Design theorists argued that jobs could be and should be fitted to human needs.

The basic tenets of Job Design are relatively straightforward. Following on from the work of Maslow, it is argued that work should be organised in such a fashion that it allows people to fulfil their needs as human beings. The view is that Scientific Management, with its emphasis on removing autonomy and discretion from workers and on fragmenting jobs, is counter-productive to individual fulfilment. This in turn, it is argued, is damaging to the performance of the organisation, because boring, monotonous and meaningless jobs lead to poor mental health, and engender feelings of dissatisfaction in workers who have to perform them, which in turn leads to lack of motivation, absenteeism, labour turnover, industrial unrest and even sabotage. Phrases such as "blue collar blues" and terms like alienation have been used to describe this process.

The solution to these problems follows from the analysis. If Tayloristic trends in job design are counter-productive, then they should be reversed and "variety, task completeness and, above all, autonomy" should be built into jobs Wall et al, 1984, p 15). This would increase workers' mental health and job satisfaction, which in turn would lead to increased motivation and performance. Just as Taylor believed his system would benefit both workers and management, so too do the proponents of Job Design; the difference is that the benefit to workers is personal fulfilment and development rather than increased wages, though in both systems the benefit to management is increased productivity (Blauner, 1964; Davis and Canter, 1955· Friedmann 1961· Hackman and Lawler, 1971; Herzberg et al, 1959· Kelly 1982 a and b).

In practice, there are three main variants of Job Design Job Enlargement, which concentrates on increasing work variety either by combining previously fragmented tasks together or b rotating people between different types of work (Guest, 1957); Job Enrichment, which concentrates on increasing workers' control over what they do by re-arranging work so that some of the responsibilities previously carried out by supervisors and support personnel are given either to individual workers or, a later development, semi-autonomous work groups (Herzberg, 1968); and Socio-Technical systems theory, a variant on Job Design which emerged in the 1950s and which involves a shift of focus from the individual job to the organisation as a whole. Socio-Technical theory sees organisations as being composed of interdependent social and technical systems; the theory argues that there is no point in re-organising the social system in isolation from the technology, and that individual and organisational performance is dependent upon the degree of fit between the two. This view sees technology as acting as a limitation on the scope for redesigning individual jobs (L E Davis, 1979; Trist et al, 1963).

As mentioned above, Job Design has emerged as the major alternative to the precepts of Scientific Management for the design of jobs and work organisations in Western society. In order to understand why this should be so, it is necessary to recognise, as Davis and Canter (1955) noted when first introducing the concept of Job Design, that jobs and work organisations are social inventions put together to suit specific needs and reflect the culture, the ideology and the governing concepts or ethos of the time. Therefore, in examining the appeal of Job Design, it is necessary to be aware of the social and economic changes that were taking place in post-World War Two Western society, and how these affected individuals and organisations.

There are three main reasons why Job Design has become so influential as a theory.

The first was related to the collectivist ethos and economic policies that emerged from World War Two. Just as Scientific Management reflected the divided and antagonistic milieu of pre-World War One and Inter-War societies, so Job Design reflected the Keynesian consensus that emerged after 1945. Not only was there a greater commitment to equality in society, a feeling that all should benefit from a nation's wealth, but this was also reflected in the full-employment policies pursued by governments. These policies led to a "changed distribution of power between capital and labour [and] enhanced trade union bargaining power" (Kaldor, 1983). This, coupled with increased expectations by workers, led to a rejection, both at a collective and individual level, of boring, monotonous, and tightly-controlled jobs. This was manifested in labour turnover, industrial unrest and many other ways. Thus, at a societal and an organisational level, there was a willingness, and a need, to examine and develop more humanitarian methods of organising work (Cherns, 1982; Friedman, 1978; Kelly, 1982b).

The second reason relates to one of the issues raised by the Hawthorne experiments: the existence of informal systems within the formal organisation of work. It became apparent that it was neither possible nor practicable to control all that a person did whilst at work; although certain aspects could be monitored and closely controlled, others could not. From this, it became clear that elements of willing co-operation by workers were necessary if organisations were to operate efficiently. Therefore, for this reason, more co-operative methods of work organisation were sought (Burawoy, 1979; Katz, 1973; Purcell and Earl, 1977; Selznick, 1948; Strauss et al, 1973; van Aken, 1978).

The third reason, and the one that was probably most influential in pushing individual organisations into change programmes, was linked to market changes brought about by such factors as the removal of barriers to international trade. The pre-World War Two system of tariffs and import controls was removed and companies faced not only domestic competition but also international competition. In these circumstances, it became apparent that rigidly-defined and controlled jobs and work organisation could act as a barrier to flexibility and increased productivity. Certainly, Kelly (1982b), in his major review of Job Design, found that it was economic reasons aimed at increasing productivity, decreasing staffing levels and increasing the flexibility of production which tended to lead to job redesign rather than humanitarian reasons.

Therefore, for a variety of reasons, especially changing product and labour market conditions, Tayloristic forms of work organisation were being rejected both by workers and managers. New ways of designing jobs, based on the premise that motivation and co-operation were necessary for efficient working, emerged. Managers began to recognise that the detailed control of individual workers was not an automatic corollary to the overall control of production and the pursuit of organisational goals. This was especially the case where a reduction in detailed control of work and the expansion of work roles led to greater stability, predictability and flexibility of production, by increasing workers' satisfaction (Cammann and Nadler, 1976; Gorz, 1976; Kelly, 1982b; Pignon and Querzola, 1976; Williams and Steward, 1984).

In the decades since the Second World War, most European countries have initiated some form of officially sponsored "Work Humanisation Programme". Norway and Sweden have led the way both in terms of financial and legal backing, but other countries, notably West Germany, have also initiated Government-financed programmes as well. In Britain, however, despite the establishment of the Work Research Unit in 1974, the backing from Government seems less than enthusiastic and it is left, in the main, to individual organisations to provide the initiative for change. It also tends to be the case in North America that "Quality of Working Life" programmes by organisations are the result of internal rather than external encouragement. Nevertheless, there can be no doubt that Job Design precepts have permeated Western society on a large scale.

Yet despite the impact of Job Design theory, Scientific Management is still, in practice, more influential in the design of jobs and work organisations than its newer rival. Even where change programmes have been initiated, there have been many failures or cases where the changes have not been sustained over time (Child, 1984; L E Davis, 1979; Sell, 1984b; Taylor, 1979; Wilkinson, 1981).

There appear to be three key reasons why Job Design has failed to supersede Scientific Management, which are as follows:-

i) That Taylorism is not just a blueprint for the fragmentation of jobs and control of workers: it is in fact part of a powerful and dominant ideology regarding the nature of work and the role of workers, which developed in the 19th century and which is still influential in forming the beliefs and values of managers today. Job Design theory appears to have had only limited impact in challenging this ideology, and therefore many managers still believe that fragmenting jobs and removing workers' discretion is the most effective way of designing jobs from the point of view of organisational needs (Bibby et al, 1979; Hedberg and Mumford, 1975; Mumford, 1979; Mumford, 1981; Rosenbrock, 1981; Sell, 1984b; Taylor, 1979; Williamson, 1973).

.) That there are substantial managerial and technical barriers which prevent change. The two main characteristics of Job Design are increased control and increased variety for workers. Yet in order to increase workers' control, it is often, in fact almost always, necessary to reduce the power, and therefore the status, of supervisors and/or lower management. In some cases, their jobs may be eliminated altogether. The co-operation of these people is often essential if successful change is to take place, but instead of co-operation, their most likely reaction will be resistance. As for increased task variety for workers, this is often only possible if the technology employed is modified or changed altogether. As this can be a very costly exercise, it is unlikely to take place (Bjorn-Andersen, 1983; Clegg, 1984; Davis and Taylor, 1979; Hickson and Butler, 1982; Klein, 1984; Pfeffer, 1981; Tipton, 1982).

iii) That existing organisational structures block or undermine change. On the one hand, organisational inertia makes it difficult to convince managers that the great effort needed to initiate and carry through structural changes is worthwhile. On the other hand, the fact that Job Design experiments tend only to change one part of the organisation, leaving the rest untouched, are likely, because the new procedures and practices are incompatible with the rest of the organisation, to fail or be disregarded (Clegg and Fitter, 1981; Friedlander and Brown, 1974; Gough and Stiller, 1983; Pfeffer, 1981).

Therefore, for a variety of reasons, Job Design has failed to effect widespread change.

CONTINGENCY THEORY

Contingency Theory, like Job Design, emerged in the wake of World War Two. In part, again like Job Design, it was a reaction to, and a rejection of, Scientific Management. But, unlike Job Design, which concentrates in the main on the design of individual jobs, Contingency Theory is concerned with the entire organisational structure rather than just parts of it.

With the ending of the Second World War, organisations had to adjust to the shock of moving from a planned and tightly-controlled war economy back to a free-market economy, albeit Keynesian-style. The dislocation that this caused would in any case have raised questions regarding the impact on organisations of sudden changes in their environment. However, also present was a reaction against

Taylorism; there was a questioning of the previously unchallenged view that there was "one best way" for all firms to be organised in order to be competitive. There were also two other factors present which posed questions about the determinants of organisational structure. One was the development of automation, which was bringing about large-scale changes in technology; the other was the growth in company size, and especially the emergence of multi-national corporations. Therefore, for these reasons, questions about the impact of environment, technology, and latterly size, on the structure of organisations were beginning to be asked (Barratt-Brown, 1972; Bright, 1958; Cherns, 1982; Clegg and Fitter, 1981; Robinson, 1953-4).

What emerged from this process was a view that organisations were not the closed and changeless entities they had been considered to be; that in fact organisations were "open systems", the structures of which were dependent or "contingent" on a range of situational variables. In turn, it was argued, the performance of the organisation was dependent upon its structure.

Thus the belief that a "one best way" for all organisations to structure themselves was replaced by a view that there was a "one best way" for <u>each</u> organisation. Contingency Theory puts forward the view that every organisation faces different situational variables; managers who are involved in organisational design have to assess the situational implications of the contingencies they happen to face. Thus the role of management is to fit their organisational structure to the contingencies that emerge, and by so doing, they will ensure good organisational performance.

However, Contingency Theory conflicts not only with Scientific Management but also, to an extent, with Job Design. According to the latter, good organisational performance is dependent upon creating satisfying jobs, but according to Contingency Theory, it is achieved by structuring the organisation to cope with one or more situational variables.

Burns and Stalker (1961), two early proponents of Contingency Theory, argued that there are two basic types of structure that organisations can adopt to cope with contingencies. The first is a Mechanistic Structure; this refers to rigid and tightly-controlled structures which, they advocate, would be appropriate in stable and predictable environments. On the other hand, in environments which are complex, uncertain, and rapidly-changing, they advocate an Organic Structure. This is a loose and flexible structure which could easily cope with sudden changes and high levels of uncertainty.

Whilst Job Design practices would fit in with an Organic Structure, the Mechanistic Structure would be more suitable for Scientific Management precepts.

Therefore, in terms of work organisation and job design, Contingency Theory appears to accommodate both Scientific Management and Job Design, depending upon the situation the organisation finds itself in (Child, 1984; Hendry, 1979 and 1980; Katz and Khan, 1978; Mansfield, 1984; Pettigrew, 1973; Wood, 1979).

The situational variables which have been cited in the literature as having most impact on structure are:- environmental uncertainty and dependence; technology; and size. Mintzberg (1979) has suggested that other contingencies, such as the age of the organisation, are also relevant, but it is the latter three which are considered most important. However, there is no consensus amongst contingency theorists as to which of these three factors is most important, though those who support the view that environment is the key contingency argue that the survival of an organisation depends upon maintaining a balance of exchange transactions with the environment sufficient to provide resources for future activity. It is recognised that the management of an organisation is undertaken in conditions of uncertainty and dependence, both of which create risk for management. Uncertainty arises from an imperfect understanding of events and from incomplete control over the actions taken both by employees and parties outside the organisation. These sources of uncertainty make prediction a hazardous exercise. The dependence of management upon the goodwill and support of other groups, both inside and outside the organisation, carries with it an element of vulnerability with regard to the success of its policies and possibly to the survival of the organisation in its present form.

The levels of uncertainty and dependence, and therefore risk, facing management will vary between different cases, but these factors will never be wholly eliminated. This lack of perfect control over the organisation's environment means that the context and conditions in which its work is carried out have to be regarded as contingencies: that is, they are relevant and variable parameters for which allowance and adjustment in management practices and organisational design have to be made (Hage and Aiken, 1967; Lawrence and Lorsch, 1967; Sadler and Barry, 1970; van Aken, 1978).

The argument for technology being the key variable follows similar lines as the argument for environment. However, there are distinct variants of it which reflect different definitions of technology at the organisational level of analysis that theorists and researchers have employed (Hickson et al, 1969).

The two most developed approaches are probably found in Woodward's (1965 and 1970) studies of the "operations technology" of manufacturing organisations, and Perrow's (1967 and 1970) more generally applicable analysis of "materials technology". Operations technology refers to the equipping and sequencing of activities in an organisation's workflow, whilst materials technology refers to the characteristics of the physical and informational materials used. Both Woodward and Perrow consider that the nature of technological variables present important implications for the design of effective organisational structures. As an example, Woodward (1965) described three types of materials technology, which related to Unit production, Batch production and Mass production. She argued that each type of technology had its own most appropriate structure and that if, say, the structure appropriate for unit production technology was grafted onto mass production techniques, it would result in sub-optimal organisational performance. This view is also shared by other writers such as Thompson (1967) and Zwerman (1970).

The third contingency is size; for many, this is the key variable that influences structure. This argument has a long antecedence within organisational theory, being first cited by Weber (1947). However, in terms of Contingency Theory, its main proponents are the Aston School (Pugh et al, 1969 a and b), who found that larger size was the most powerful predictor of higher values on their main structural factor, which related to the bureaucratic dimension of specialisation, use of procedures, and reliance on paperwork. Blau (1970) has suggested that increased size generates structural differentiation within organisations, which in turn enlarges the absolute size of the administrative component.

There are two strands to the argument for the importance of size, both of which have similar ultimate implications for effective structural design. The first argues that increasing size offers more opportunity to reap the benefits of increased specialisation. This is likely to manifest itself in the form of greater structural differentiation, which exhibits high heterogeneity amongst sub-units. This in turn makes managerial co-ordination of sub-unit activity more difficult, especially as tendencies towards functional autonomy may well appear. Therefore, for this reason, pressure will be placed upon senior managers to impose a system of impersonal controls through the use of formal procedures, the recording of information in writing, etc. The second argument reaches a similar conclusion by pointing out that the problem of directing larger numbers of people makes it impossible to continue to use a personalised, centralised, style of management. Instead, a more decentralised system, using impersonal mechanisms of control, has to be developed. The operation of such a system requires higher numbers of administrative and clerical personnel (Child, 1972a).

It is easy to see why, in the changing economic and technological environment after 1945 and with the tendency towards larger and larger organisations, Contingency Theory has become so attractive to organisational theorists. Indeed, it has become, in the 1970s and the 1980s, the dominant perspective on organisational design. However, despite its widespread acceptance, the evidence against it, both at a theoretical and practical level, is very strong, as Azma and Mansfield (1981), Child (1972 a and b and 1984), Hendry (1979 and 1980), and Wood (1979) have all pointed out.

There are nine main criticisms of Contingency Theory, which are as follows:-

i) Probably the most damaging criticism relates to the posited link between structure and performance. A number of writers have drawn attention to the problem of adequately defining "good performance", and they point out that, in the literature, there is no agreed definition of this. Therefore, it becomes difficult to determine whether or not an important link does exist between structure and performance. This has led some researchers to argue that no such link has been satisfactorily established. If this is the case, then obviously the whole basis of Contingency Theory is undermined (Child, 1984; Hendry, 1979 and 1980; Mansfield, 1984; Terry, 1976; Wood, 1979).

ii) Organisations have to accommodate multiple contingencies. Khandwalla (1973) has suggested that these can be jointly fitted to structure. However, each contingency may have a different implication for organisational design. Thus, conflict between contingencies, causing tension and other problems of integration, can arise. This may be one of the reasons why structure rarely emerges as a strong correlate of performance (Child, 1984; Wood, 1979).

ii) Contingency Theory assumes that organisations pursue clear-cut, well thought-out, stable and compatible objectives. However, in practice, they may pursue a number of different and conflicting goals at the same time. It can also be the case that the choice of organisational goals can affect structure, rather than other factors.

iv) Rather than the environment affecting the organisation, the reverse may, in some cases, be the case. Such measures as advertising or vertical integration can have a significant impact upon the environment in which an organisation operates (Hendry, 1979 and 1980; Liefer and Huber, 1977; Wood, 1979).

v) Despite the length of time Contingency Theory has been in circulation, there is still no agreed definition for either technology or environment. The literature gives a wide and conflicting range of definitions for these two variables which, therefore, make it difficult to prove a relationship between these factors and structure. In this situation, it comes as no surprise that the result from some studies challenges whether or not an important relationship does exist between situational variables and structure (Dastmalchian, 1984; Hendry, 1980; Mansfield, 1984; Pugh and Hickson, 1976; Warner, 1984).

vi) Whilst a relationship does appear to exist between size and structure, it does not appear to have an appreciable impact on performance. Some researchers have suggested that the link between size and structure relates to preferred systems of control which may have little or nothing to do with performance. Indeed, it has been noted that Woodward, in her later work (Woodward, 1970), suggested that control systems might be a mediating variable between contingencies and structure; this would be consistent with the arguments in the two previous sections regarding control objectives and work organisation (Child, 1984; Hendry, 1980; Mansfield, 1984; Marginson, 1984; Wood, 1979).

vii) Researchers, in comparing contingencies, structure and performance, use the organisation's formal structure for comparison purposes. Yet, as Woodward (1965) has noted, formal structures, as laid down for example in organisation charts, fail to show important organisational relationships which, taken together, may have a significant impact upon performance. Therefore, by examining the organisational structure as laid down by management, researchers may be using inaccurate or incomplete data, and thus reaching erroneous conclusions (Argyris, 1973; Burawoy, 1979; Selznick, 1948).

viii) Rather than managers being the prisoner of organisational contingencies when making decisions regarding structure, almost the reverse may be the case. It appears that managers have a significant degree of choice not only about organisational structure but also about situational variables. Whether this is called "Strategic Choice" (Child, 1972 a and b); "Organisational Choice" (Trist et al, 1963); or "Design Space" (Bessant, 1983), the meaning is the same:

those senior managers who are responsible for decision-making can exercise a high degree of freedom in the selection of the technology to be used, the environment in which they operate, and the size of the organisation and its structure. Indeed, Perrow (1983), one of the architects of the technology - structure hypothesis (Perrow, 1967 and 1970), now argues that technology is chosen and designed in order to maintain and reinforce existing structures and power relations within organisations rather than the reverse (Abell, 1975; Child, 1984; Clegg, 1984; Hendry, 1979; Lorsch, 1970; Mansfield, 1984; Wood, 1979).

ix) Contingency Theory is too mechanistic and deterministic, and ignores the complexity of organisational life. There is a need to see organisations as political systems rather than rational, deterministic ones. In this view, structure becomes the product of a series of clashes between individuals and groups within the organisation, fighting to increase or maintain their power and influence (Buchanan, 1984; Hendry, 1979; Hickson and Butler, 1982; Pfeffer, 1981; Wood, 1979).

Therefore, for all the above reasons, Contingency Theory, despite its appeal, fails to provide convincing guidelines for the design of organisational structure.

THE LABOUR PROCESS

Over the last decade, there has been a major resurgence of interest, by Marxists and non-Marxists alike, in Labour Process theory - the Marxist critique of work organisation and job design.

However, Labour Process theory, unlike Job Design and Contingency Theory, does not put forward alternatives to Scientific Management, but instead argues that in capitalist economies, organisations have no alternative but to control and exploit their workforces by the use of Tayloristic techniques and deskilling technology, in order to remain profitable and so survive (Braverman, 1974).

In order to understand why this should be so, it is necessary to understand the basis of Labour Process theory and the reasons for its current resurgence in popularity.

Whilst discussion of the Labour Process was one of the central themes of Volume One of Marx's "Capital" (Marx, 1886), it was virtually ignored by Marxists until the 1960s. Instead, Marxists concentrated their attention on macro-level manifestations of capitalist development, especially the rise and consolidation of large-scale, monopoly, capital. The focus of attention shifted from capitalist methods of minimising costs and maximising workers' effort and productivity; instead, it was argued that the major problem faced by monopoly capitalism was to maintain demand for products in economies saturated by consumption goods. The view was that, in this situation, sales and profits were less dependent upon price than upon the nature of product markets. This, therefore, concentrated attention on the strategies that organisations adopted to protect, divide and create markets, rather than the actual costs and methods of production (Baran and Sweezy, 1968; Tarling, n.d.). Because the focus moved from problems of production to problems of marketing, little attention was paid by Marxists to job design and work organisation and how these affected organisations' ability to compete.

However, in the 1960s, this gap in Marxist theory was raised by Baran and Sweezy (1968), in their study of the development of monopoly capital. They argued that an examination of the Labour Process was essential to any comprehensive study of how organisations and economies functioned under monopoly capital. Even so, it was another eight years before Braverman (1974) produced his now famous study of "Labor and Monopoly Capital", which attempted to fill this gap and to re-establish the central importance of Labour Process theory to the Marxist debate on the development of capitalism.

Braverman began by restating the basic tenets of Marxism as they apply to the capitalist production process. These are that, under capitalism, the means of production - raw materials, tools, etc. - are owned by a small elite, the capitalist class. However, labour-power must be employed in order to transform the raw materials into products. This is why Marx believed that only labour created value, because without labour, the tools of production would remain idle, the raw materials would not be transformed, and the capitalist would have no products.

However, the production of a commodity is not enough for the capitalist; it must be capable of being sold, in competition with similar products, in order for the capitalist to make a profit, accumulate further capital and thus stay in business. Therefore, the costs of production must be less than the market price of the product. As only labour creates value, this is achieved by denying workers the full value of their labour. This constitutes the basis of Marx's view that capital must exploit labour, deny workers the full value of their effort, in order to survive in business. Marx argued that, under capitalism, the tendency was for the rate of exploitation to increase, because capitalists must compete against each other to sell their goods, and only those who produced the cheapest goods - i.e. only those capitalists who could effect the greatest level of exploitation - would stay in business.

Therefore, to ensure profitability, the capitalist must organise the production process - the Labour Process - in such a way as to maximise output and minimise costs. The result, according to Marx, is that a fundamental and irreconcilable conflict exists between capital and labour. On the one hand, the capitalist, in order to stay in business, must extract as much work as possible for as little pay as possible; on the other hand, workers will resist this exploitation and seek to obtain the full value of their labour power (Braverman, 1974; Marx, 1886).

Braverman then goes on to examine the development of work organisation and job design in the 20th century. His analysis is built around three central propositions:-

i) That modern industry and commerce is run by a homogeneous managerial group who pursue, consistently and single-mindedly, the imperative of profit-seeking and capital accumulation;

ii) That because of the openly-exploitative nature of the employment relationship, management assume that they are dealing with a refractory workforce who do not willingly display loyalty, commitment and effort;

iii) That the management response to these conditions is characterised by a preoccupation with labour control, which is manifested through the use of Scientific Management techniques and changes in technology which together deskill labour and reduce the dependence in the production process on human intervention and control.

The publication of Braverman's book acted as a catalyst for a large-scale re-opening of the Labour Process debate. However, before examining the main criticisms of Labour Process theory which emerged from this debate, it is important to understand the context in which the renewed interest in the Labour Process is taking place.

As mentioned earlier, the period up to the mid-1960s saw little interest by Marxists in the Labour Process. The explanation for this is two-fold. Firstly, as mentioned above, the rise, and problems, of monopoly capital had become the main preoccupation of Marxists; and secondly, developments within organisations appeared to contradict the Marxist orthodoxy that, as capitalism developed, workers would face increasing exploitation and unemployment. The adoption of Keynesian economics in this period led to full employment, rising real wages, an expansion of general welfare provision, and a change in managerial philosophy. As described in the section on Job Design, there was a move from confrontational management policies to more co-operative initiatives. These developments within organisations were, by and large, ignored, or written off, by Marxists, who found them difficult to incorporate within the framework of Marx's theory of capitalist development (Crouch, 1980; Friedman, 1978; Gamble and Walton, 1976; Storey, 1983; Thompson, 1983).

Nevertheless, there were underlying trends in this period which would lead to a renewed interest by Marxists in the Labour Process. The key development taking place was the decline in the rate of profit, which was parallelled by a rise in unemployment and inflation. In Britain, the pre-tax rate of profit declined steadily from 16.5% in the period 1950-4 to 9.7% in the period 1970-4 (Storey, 1983).

The declining rate of profit, coupled with the rise of inflation, led to the rationalisation of production capacity, in order to reduce costs, which in turn led to the inexorable rise in unemployment. What emerged as a minor problem in the 1960s mushroomed into a major world economic crisis in the 1970s. The enormous pressure upon management to reduce costs led, initially, to a shake-out of labour but, as the crisis deepened, attention turned to other methods of cutting costs and increasing productivity such as work re-organisation, and changes in technology. The rise in unemployment also brought about a reduction in the bargaining strength of labour and a resurgence of managerial power, which many commentators saw as a pre-requisite for the re-organisation of the production process. Managers began to rely less on co-operation and more on imposition as a method of implementing change. In some cases, such as at British Leyland, there were quite dramatic changes in management style as a prelude to wholesale changes in work organisation and technology (Gamble and Walton, 1976; Kaldor, 1983; Scarbrough, 1984; Storey, 1983; Thompson, 1983).

For two reasons, this brought about a renewed interest in the Labour Process theory. Firstly, Marx had asserted that in capitalist crises, the misery and exploitation of labour would increase. The increase of managerial power, the drive to cut costs, and the rise in unemployment seemed to bear this out. Therefore, it was a situation more conducive to a Marxist analysis than had previously been the case. Secondly, as markets collapsed, the focus of attention changed from marketing strategies to production costs and methods. In this situation, it is not surprising that a renewed interest in Labour Process theory should emerge.

The focus for this debate is still Braverman's book on "Labor and Monopoly Capital", which has been hailed as a Marxist classic, and has been praised by many as a highly important work (Heilbroner, 1975; Rowthorn, 1976; Storey, 1983; Thompson, 1983). Yet it has also attracted much criticism, even from Marxists (Friedman, 1978; Nichols, 1977). All concede that the book is of outstanding quality, but they also accuse Braverman of serious shortcomings, including the view that his analysis is based upon shaky theoretical grounds (Brighton Labour Process Group, 1977; Elger, 1979).

There are in fact eight major criticisms of Labour Process theory as developed by Braverman, which are as follows:-

i) That Braverman over-estimates both the homogeneous nature of management and their ability to pursue, single-mindedly, the profit motive. Critics point out that not only are management split vertically by status and horizontally by function, but they are also separated by the different goals they pursue. It is, for instance, the norm that middle and junior managers pursue short-term, narrow output measures rather than profit per se (Buchanan, 1984; Coombs, 1978; Edwards, 1983; Hickson and Butler, 1982; Rose and Jones, 1983; Storey, 1983).

ii) That Braverman over-estimates managers' foresight, knowledge and ability to plan ahead. Whilst in some organisations management may be able to carry out consistent and well-planned control strategies, this appears not to be the case in many other organisations. In these cases, control strategies tend to be piecemeal and variegated, and may be responses to situations as they arise rather than the product of conscious planning. Indeed, one recent criticism of British managers is that they pursue short-term tactics rather than long-term strategy (Brown, 1983; Buchanan, 1984; Burawoy, 1979; Edwards, 1983; Rose and Jones, 1983; Storey, 1983).

iii) That Braverman concentrates too much on Scientific Management as <u>the</u> control strategy, thus ignoring the evidence that management have at their disposal a wide range of techniques for ensuring production such as Job Design, welfarism, and paternalism, and that many of these do not involve the need for management to control in detail what workers do (Burawoy, 1979; Edwards, 1983; Friedman, 1978; Nichols, 1977).

iv) That Braverman fails to realise that all systems of work must include some element of co-operation or consent by labour and that, therefore, managers may, and usually will, choose to pursue consent as well as control in order to achieve production goals. After all, control is not an end in itself, but a means to an end, and therefore if objectives such as production quotas and, especially, quality, can be more efficiently achieved by gaining the consent and co-operation of workers, then managers may seek to do this. It is also the situation that, whilst an antagonistic relationship between capital and labour may exist, it does not mean that open conflict will take place, and in any case, as well as conflict, there is also an interdependence between capital and labour in that capital needs workers and workers have an interest in the survival of the unit of capital employing them (Buchanan, 1984; Burawoy, 1979; Cressey and MacInnes, 1980; Edwards, 1983; Littler and Salaman, 1982).

v) Braverman sees an irreversible and inevitable trend towards deskilling under capitalism; yet this may not be so. Certainly, compared with pre-industrial or early industrial craftsmen, modern factory workers are less skilled, but compared on a decade by decade and an industry to industry basis, as some studies do, the tendency towards deskilling does seem debatable (Davis, 1975; Lazonick, 1979; Montgomery, 1979; Palmer, 1975; Storey, 1980; Storey, 1983).

vi) Braverman concentrates on the formal system of work organisation as laid down by management, and ignores the power workers have to modify this and, to an extent, mould it to fit their needs. Therefore, managers' control over workers is not as great as an examination of the formal system of work organisation or responsibilities might imply (Buchanan, 1984; Burawoy, 1979; Purcell and Earl, 1977; Storey, 1983; Thompson, 1983).

vii) Braverman assumes that management is all-powerful and that workers are forced to accept the control strategies that management put forward. Yet there is evidence that workers' resistance, either at an individual or at a collective level, can cause management to modify or reverse their intentions. In any case, as mentioned above, what management appear to have imposed on workers in terms of work organisation, and what actually takes place in practice, can be two different things (Burawoy, 1979; Edwards, 1979; Friedman, 1978; Lee, 1980; Penn, 1982; Storey, 1983; Thompson, 1983).

viii) Braverman sees technology as being deterministic and deskilling, yet the evidence from studies of the introduction of new technology, as outlined in Chapter One, tend not to confirm this view (Buchanan, 1984; Lee, 1980; Thompson, 1983).

Therefore, Labour Process theory, like the other approaches to work organisation and job design discussed in this chapter, is not without its problems.

CONCLUSION

As can be seen, these are four important but contradictory approaches to the understanding of the determinants of work organisation and job design. What unites them is that they all imply that good organisational performance is dependent upon the adoption of a particular method of work organisation and job design, and that, therefore, the scope for choice in this area is minimal or can only be exercised at the expense of profitability.

Those who advocate Scientific Management precepts believe that tightly-controlled and narrowly-defined work structure and jobs are in the best financial interests of the organisation and also of individual workers.

Job Design advocates believe the reverse is true; that Tayloristic precepts lead to low job satisfaction, mental health problems, lack of motivation, absenteeism and labour turnover, which not only are bad for the individuals involved, but also adversely affect organisational performance. Instead, they advocate the design of jobs and work organisation which allow variety, task completeness and autonomy. This is seen as leading to good organisational performance because it increases individual satisfaction, motivation, and performance.

Contingency Theorists ignore the contribution of individual workers to organisational performance and concentrate on the determinants of structure. Their view, that performance is dependent on the fit between structure and situational variables, leads them to advocate structures which would accommodate Job Design principles or Scientific Management principles, depending on the circumstances faced by the organisation. Therefore, once again, choice is limited; good performance is dependent upon adopting the appropriate structure for the situation.

For Labour Process theorists, once again, there is no choice for organisations operating in capitalist economies. Organisational performance and survival are dependent upon using Tayloristic techniques and deskilling technology to control and exploit workers.

Therefore, with all these approaches, ignoring the fact that they actually contradict each other, the scope for choice regarding work organisation and job design is constrained. However, the individual criticisms of these approaches present a different picture of the constraints organisations face when making decisions in these areas. Instead of decision-making being seen as a rational, almost mechanical, process, what emerges is a picture of the internal workings of organisations which is far more complex and far less rational than is acknowledged by any of the four approaches examined. Instead of organisational decision-makers having little choice in the design of work structures and jobs, they appear to have a high degree of latitude in these and other areas. However, the freedom of choice they enjoy appears to be constrained and directed by a variety of factors both external, such as culture, ideology, economic and social climate, etc., and internal, such as the values, attitudes and self-interest of decision-makers, organisational goals and managerial strategy, etc.

It follows from this that, in constructing a conceptual framework in which to understand how organisations will cope with new technology and what the impact of that technology will be, these factors form an important part of that framework.

By drawing together the arguments presented in this and the previous two chapters, Chapter Four will put forward such a conceptual framework, and show which factors are important in understanding the process and outcomes of technological change.

CHAPTER FOUR

CHOICE AND NEW TECHNOLOGY: A CONCEPTUAL FRAMEWORK

Introduction

The impact of new technology upon work organisation and job design is dependent upon the choices made with regard to the selection of the technology and, most importantly, how it will be used. Chapters 1 - 3 have attempted to identify the key factors which influence these choices, by examining the literature on new technology and the development of, and approaches to, work organisation and job design. This chapter will draw together the arguments developed in those three chapters in order to create a framework within which to understand how organisations and their members react to technical change.

This chapter will conclude by arguing that there is a general tendency in British industry to design work structures and jobs in accordance with the precepts of Scientific Management, and that this will significantly influence the way that new technology is used. However, this tendency will be mediated by factors external and internal to individual organisations which may lead to other outcomes.

THE ARGUMENTS FROM CHAPTER ONE

Chapter One reviewed the literature on new technology, with special reference to its impact upon work organisation and job design. What emerged was that there was no agreement amongst writers and researchers as to what effect new technology would have. Some argued that it would create worse jobs, others that better jobs would be the result; however, it *was possible to* produce evidence that both had happened. This led to a rejection of the argument for technological determinism; it was pointed out that whilst technology might limit choice, it did not eliminate it altogether. Instead, it was argued that the effect of technological change would vary from country to country, industry to industry, and organisation to organisation, depending upon a wide range of general and specific factors. The factors which were seen as restricting and guiding choice were:-

* Power relations within organisations
* The structure of the organisation, and its philosophy/culture
* The organisation's market and products
* The size of the organisation
* The values, attitudes and self-interest of the individuals involved
* Societal differences
* Historical developments, both within and between countries.

The chapter concluded by pointing to the need to examine the historical development of jobs and work organisation, and dominant approaches to these issues, in order to gain a deeper understanding of the factors which influence the process and impact of technological change.

THE ARGUMENTS FROM CHAPTER TWO

Chapter Two examined the emergence and development of modern work organisation and job design from the Industrial Revolution to the beginning of the 20th century.

It was argued that the factory system emerged for organisational reasons relating to the control and co-ordination of labour, rather than to take advantage of specific technological developments. Furthermore, it was contended that technological advances in this period were driven and shaped by the needs of factory owners to control and cheapen labour.

The pattern of work organisation and job design which emerged in Britain in the 19th century was based upon the belief that the division of labour and the fragmentation of jobs and skills was the most effective way of controlling labour and reducing costs. These developments generated technical change, and also created the need for a plethora of separate supervisory, managerial and technical functions, thus creating organisations where functions were split not only vertically, but horizontally as well.

In terms of shop floor workers, the tendency was for the multi-skilled craftsman to disappear and for some of his decision-making functions to go to staff specialists, whilst his manual skills would be split amongst lower-paid, semi- or unskilled workers. This process was encouraged by economic developments which not only created bigger markets, but also generated more competition, thus putting pressure upon individual organisations to increase production whilst reducing unit costs, more often than not labour costs.

These developments brought in their wake the creation of trade unions designed to protect, and resist changes in, craft status and wages, and which in turn laid the basis for present-day forms of industrial relations.

Towards the end of the 19th century, America began to overtake Britain as the world's premier industrial nation. The problems of organisation and control which faced managers in Britain were more pronounced in America because of the greater size of organisations and the more volatile management-worker climate. Managers in the United States sought a method of work organisation and job design which not only increased their control over workers, but which also legitimated it. What emerged was Scientific Management, which was a set of precepts for reducing the role and importance of individual workers in the production process.

Both in Britain and America, these developments incorporated and were underpinned by an ideology which saw workers as unreliable, recalcitrant, motivated only by money, and who, if not controlled or eliminated from the production process, would threaten the continued profitable existence of organisations.

THE ARGUMENTS FROM CHAPTER THREE

Chapter Three examined four key approaches to work organisation and job design in order to understand the theoretical and practical developments that had taken place in these areas in the 20th century.

The first of these approaches was Scientific Management, which, it was contended, has become the dominant managerial practice in Western society in the 20th century. It was argued that Scientific Management is a set of precepts for deskilling, cheapening, and controlling workers; however, in terms of organisational and individual efficiency, it is seen as having serious drawbacks. Firstly, the creation of a plethora of separate departments pursuing differing, though theoretically compatible, goals could lead to inter-departmental friction and conflict which would produce a sub-optimal overall organisational performance. Secondly, the designing of jobs that had little scope for the exercise of skill and choice has a detrimental effect upon workers' satisfaction and motivation and leads to the pursuit of instrumental goals, and can result in poor industrial relations. This not only affects organisational performance, but also acts to reinforce managerial beliefs about workers' recalcitrance and lack of motivation, and thus becomes a self-fulfilling prophecy.

The second approach, Job Design, arose partly as a reaction to Scientific Management and partly as a product of the changed economic and social climate that emerged after the Second World War. Job Design theory advocates the redesigning of jobs in such a way that they provide skill, autonomy and variety. It is underpinned by theoretical research and practical experiments within organisations which have shown that workers not only have physiological needs which can be met by monetary payment, but also have psychological needs which can only be met by jobs which are intrinsically motivating, and allow them to develop their skill and knowledge, and to exercise control over what they do. Researchers also discovered that whilst organisations are composed of formal rules and structures, workers create or negotiate their own informal systems of rules and norms within these. This development revealed not only that workers are capable of exercising more control over the work process than the formal system would appear to allow, thus scotching the Tayloristic belief that it is possible to control all that workers do, but also that these informal systems are necessary in order to make the formal system work, thus demonstrating that workers' co-operation in the production process is essential.

However, whilst Job Design theory has become fairly widely established, Job Design practice has not. This appears to be for two reasons. The first relates to organisational structure and power relations. Redesigning jobs involves changing an organisation's structure, and maybe also its technology, which in itself is neither easy nor cheap, and resistance by some managers and even workers might be expected. However, it also involves taking control and skills from managers and supervisors and giving them to workers. It is unfortunate, but not unreasonable, that managers and supervisors will resist this process; and as they are often crucial to redesign experiments, it is not surprising that many of these fail or are never initiated. The second reason is that Job Design precepts conflict with the values and beliefs of many managers that workers need to be closely supervised, and only respond to monetary incentives. Therefore, for these reasons, Job Design, whilst making some advances, has failed to overthrow Scientific Management as a recipe for designing jobs and the organisation of work.

The third approach considered was Contingency Theory, which concentrates upon organisational structure rather than the design of individual jobs. It relates organisational performance to structure and views structure as being dependent upon certain contingent variables, the main ones being the organisation's environment, technology and size. Like Job Design, it arose partly as a reaction to the "one best way" approach of Scientific

Management and partly because the changing economic and technical climate after the Second World War highlighted the problems caused to organisations by changing situational variables. However, there are two main criticisms of Contingency Theory. The first is that it has proved difficult to show a link between structure and performance, and between structure and the various situational variables. Indeed, merely defining such variables as technology and environment has proved a problem. The second criticism is that Contingency Theory concentrates upon the formal organisational structure and its relationship to performance and ignores the important contribution to performance made by informal structures within the formal ones.

Critics of Contingency Theory have also argued that it over-estimates the importance of situational variables and under-estimates the significant degree of choice that managers have when deciding upon structural arrangements. The choices made are seen as emerging from a political bargaining process within organisations, whereby individuals and groups compete, lobby and make alliances in order to obtain an outcome favourable to themselves. The final outcome is not based upon rational decision-making, but upon who can exert the most power.

The fourth approach to work organisation and job design considered was that offered by Labour Process theorists. This is a Marxist interpretation of how organisations operate. At its most fundamental, it states that for an organisation to make profits and to survive, those who control the organisation have to exploit its employees. Thus work organisation and job design are geared to exploitation and, because workers are seen as recalcitrants who resist exploitation, managers consistently and single-mindedly pursue a policy of deskilling and control through the use of Scientific Management and deskilling technology.

Whilst having its roots in the 19th century, Labour Process theory, as an important approach to organisational behaviour, has only emerged within the last decade. This appears to be linked to developments in the economy which have led to changes in the balance of power between managers and workers, and is leading to changes in work organisation. However, this approach is not without its problems. It sees management as a homogeneous group when, in fact, as argued in previous chapters, it is split by both vertical and horizontal divisions, a factor exacerbated by the adoption of Scientific Management. It sees managers consistently pursuing Scientific Management objectives when, in fact, though it is the dominant practice, many organisations have either rejected it or attempted to reject it. Labour Process theorists assume that workers are reluctant participants in the production process, which may be true for some but not all; indeed, worker co-operation is essential if organisations are to function. It sees new technology as another step in the deskilling process, yet there are examples where that is not the case. Lastly, it assumes that workers are powerless to resist managerial attempts to reduce their skill and to increase control, yet evidence in chapters 2 and 3 would appear to indicate that this is not the case.

ORGANISATIONS AND NEW TECHNOLOGY

It was argued at the end of Chapter One that an examination of contemporary approaches to work organisation and job design, together with their historical development, was essential in understanding how organisations will cope with new technology. What has emerged from this examination and from Chapter One's examination of the new technology literature is that there appears to be no clear, unequivocal approach to how organisations function and thus how they will cope with new technology.

Nevertheless, it does appear from the evidence presented in Chapters Two and Three that in Britain at least, there has been, and still remains a tendency to design jobs and work organisation in accordance with the precepts of Scientific Management; that is, to create tightly-controlled and narrowly-defined jobs. However, this tendency does not apply equally to all organisations, nor does it operate with the same force all the time; it tends rather to ebb and flow.

It has become evident, from this and preceding chapters, that the impact of this tendency on individual organisations is dependent upon a range of factors which play an important role in influencing the choices that are made regarding job design and work organisation, irrespective of whether the technology concerned is old or new.

It is possible to divide these into factors which are external to the organisation and ones which are internal to it. A further division in both categories can be made between general and specific factors. These divisions are obviously arbitrary, but they do provide a useful conceptual and practical way of examining which factors influence the decision-making process and how they operate. The next two sections will examine this in detail.

EXTERNAL FACTORS

External factors are those features of the host society within which organisations operate that act to limit the choices available to, and to influence the decisions made by, organisations when designing work structures and jobs around new technology.

Sorge and Warner (1980) have pointed out that "there has been a tendency to ignore the 'societal effect approach' to organisation structure. . ." (p 318), whilst Brown (1973) has observed that:

> . . . we cannot understand the attitudes of either management or workers unless they are seen in their historical context, and unless we realise that much that has been regarded as due to 'human nature' is, in fact, purely the product of a particular culture at a particular stage of its development. (p 276)

The societal factors which influence how organisations and those in them behave can be divided into two categories: general factors and specific factors. An external general factor would apply to society as a whole and to all organisations, whilst an external specific factor would apply to the organisation in question, but not necessarily others, and certainly not all organisations. A list of general factors would include the following:-

* Nature of the political economy
* Culture
* Historical developments within and between countries
* Ideology
* Social institutions

* Political stability
* State of the economy
* State of technological development.

(Child, 1979; Littler, 1983; Mansfield, 1981 and 1984; Mumford, 1979; Rosenbrock, 1981; Williams and Steward, 1984).

A list of specific factors which affect organisational decision-making would include:-

* Product market
* Labour market
* Availability of technology.

(Child, 1984; Hartmann et al, 1983; Littler, 1983; Tarling, n.d.; Sorge et al, 1983).

Whilst both lists could possibly be extended or the headings broken down into a multitude of sub-headings, the literature does suggest that the lists given do incorporate the main external influences upon organisations. By examining firstly the general factors and then the specific factors, it is possible to see in what way they influence organisational behaviour.

A number of researchers have drawn attention to the role of the political economy in shaping organisational structure (Child, 1979; Mansfield, 1984; Littler, 1984). They argue that the capitalist or socialist nature of the economic system in which the organisation is operating will influence organisational structure, operating strategies and goals.

However, Child (1979) and others (Clark, 1979; Lammers and Hickson,1979) have suggested that the effects of the nature of the political economy are moderated by the culture of the particular society within which the organisation is based. The view is that there is an interaction between the cultural characteristics of a society and the type of organisations that are most likely to occur in that country, and there is strong support for this argument. In Britain, it has been said that organisations tend to adopt structural arrangements which follow the principles of Scientific Management (Council for Science and Society, 1981; Cross, 1984; Littler, 1983; Mumford, 1979; Williamson, 1973). In Germany, the tendency is slightly different. There is less fragmentation of jobs and skills; the division of labour is less, with the result that there are fewer specialist departments; and there is greater worker participation and a blurring of blue collar and white collar functions (Bell, 1983; Crouch, 1980; Jacobs et al, 1978; Jenkins, 1978; Sorge et al, 1983; Sorge and Warner, 1980). Sweden and Norway seem even further removed from British organisational norms and are leaders in the adoption of Job Design principles (Aguren et al, 1984; Emery and Thorsrud, 1976; Hennestad, 1982). Another notable example where the impact of culture is seen as having produced a distinctive form of work organisation is Japan. There is a strong personal commitment by Japanese workers to the company they work for and its continued prosperity. This is encouraged by the companies through such measures as guaranteed lifetime employment, subsidised housing, free education for children, and other welfare benefits, but only for some workers. The result is that Japanese managers can exercise strict discipline, which is reinforced by peer group pressure, at the same time as achieving flexibility of work. It is a system which, to the envy of others, produces both high productivity a crucial role in creating the conditions for the emergence of Job Design. Nevertheless, despite the rise of Job Design theory, the ideology which underpinned Scientific Management has not been displaced. Although for a time the popularity of Taylorism did ebb, when the British economy ran into trouble, as it did in the 1970s, the climate changed and Tayloristic values once again re-asserted themselves. There was a resurgence of the belief in the need for strong management and compliant workers. Organisations responded to collapsing markets and profits by cutting costs and re-organising production in line with Scientific Management precepts (Benson and Lloyd, 1983; Cherns, 1982; Cooley, 1980; Friedman, 1978; Gamble and Walton, 1976; Kaldor, 1983; Storey, 1983; Thompson, 1983; Williams and Steward, 1984).

This leads to the final point, which is the state of technological development. It goes almost without saying that for organisations to be contemplating technological change, there needs to be a "new" technology to change to. The introduction to this research and Chapter One described the development and growing public awareness of micro-electronics. Both in terms of the popular press and media and in terms of business publications, it is being continually portrayed as the force which will transform organisations. The climate has been created that leads organisations to believe that if they do not adopt new technology, then they will be left behind. This has been encouraged in Britain not only by government exhortation, but also by hard cash in the form of grants for new equipment. Therefore, the climate is very much orientated towards the adoption of micro-electronics (Braun and Senker, 1982; Cooley, 1984; Gunn, 1982; Large, 1982; Large, 1984b; Lynch, 1982; Shaiken, 1984; Wakeham and Beresford-Knox, 1980).

In looking at the external general factors which affect the environment within which organisations operate, two important points emerge. The first, as far as Britain is concerned, is that there is a long-run tendency for organisations to be operated and to develop along the lines prescribed by Scientific Management. The second is that this tendency can be either exacerbated or moderated by contemporary economic and social developments. With regard to new technology, it appears, from the arguments in Chapters 1 - 3 and in this Chapter, that the general tendency in the present period will be to use it in a Tayloristic manner. However, this can be moderated or exacerbated by the nature of the organisation in question.

The external factors which have particular relevance to individual organisations will now be examined to see the effect these have. There are three of these: the product market, the labour market and the technology available to the organisation. These can be dealt with relatively quickly.

In terms of the product market, it is quite possible for the rest of the economy to be depressed but for some organisations to face a buoyant market. In this case, the pressures put on other firms to cut costs to stay in business do not exist, and, therefore, if they adopt new technology at all, it may be against the tendency in society as a whole. The stability of the product market may also play a role in influencing the way that organisations choose to use new technology.

The labour market argument is similar. It is possible at times of high unemployment for shortages of particular skills still to exist. Therefore, in order to keep or attract labour, employers may have to offer jobs which are designed to be attractive to prospective employees. On the other hand, a shortage of labour may lead to the introduction of new technology to displace the skill that is in short supply. Obviously, the circumstances and choices will vary (Benson and Lloyd, 1983; Burns and Stalker, 1961; Child, 1984; Hartmann et al, 1983; Thompson, 1967; Warner, 1984).

Though there is much talk of new technology affecting all organisations, it is quite possible that for particular companies there will be, as yet, no appropriate technology developed. Therefore, they will not be able to adopt new technology, or the form of micro-electronics they do adopt will not be suitable and will be seen as a failure which may discourage its further use (ACARD, 1980; Bessant, 1982; Council for Science and Society, 1981; Sleigh et al, 1979).

As can be seen, whilst there are general factors within society which will affect organisations and influence how they use new technology, there are also specific factors which, for individual organisations, may counteract any general tendency.

However, despite external factors, it is within organisations that decisions are taken with regard to new technology, and these internal factors will now be examined.

INTERNAL FACTORS

As with external factors, it is possible to divide the internal factors into two groups: general factors, which affect the entire organisation; and factors which are specific to the decision being taken or the area where change is taking place. General factors include the following:-

* The organisation's history and development
* Its philosophy/culture
* Its structure
* Its size
* Its existing technology and products
* Its profitability/performance
* Its goals and managerial strategy
* Its management - worker relations.

Specific factors include:-

* The size and nature of the proposed change
* Sub-unit performance and importance
* The sub-unit's structure, both formal and informal
* Management - worker relations within the sub-unit
* The values, attitudes and self-interest of those involved
* The power relations of the groups and individuals involved.

Many of these factors will be influenced by external factors pertaining to the organisation and they, in their turn, as in any open system, will affect those external factors. However, it is within the organisation that both external and internal factors combine to produce the decisions regarding how new technology will be used.

The general factors affecting organisations will be examined first. Just as a society is shaped by its history and development, so it is with an organisation. Its structure, products, organisation and rules are a result of its development. Indeed, some factors within organisations can only be understood within their historical context.

One of these factors is the philosophy/culture of the organisation. The view that organisations have their own philosophies or cultures is found in a wide array of publications on organisational behaviour and theory. It arises from the concept of an organisation as a social system, a miniature society, and therefore, like all societies, exhibiting distinct cultural traits. The philosophy/culture of the organisation will be the product of the ambient society, the organisation's history and its past leadership, and will be influenced by technology, product and industry factors. These will come together to produce a set of organisational norms and values which will influence how the organisation's members behave or are expected to behave.

In fact, some writers see organisational culture as being important in gaining workers' co-operation in, and consent to, the production process. It is argued that a form of cultural indoctrination or socialisation is undergone by new recruits to the organisation which brings them to accept the organisation's view of profitability, structure and, importantly, authority as being valid.

It follows from this that philosophy/culture will be important in shaping how organisations react to change. Those where Scientific Management values hold sway will be inclined to use technology to deskill and increase control, but where other values are active, the reverse may be the case. The point is that certain methods of use will be seen as legitimate and others less so (Allaire and Firsiroth, 1984; Allen and Kraft, 1982; Burawoy, 1979; Eldridge and Crombie, 1974; Fox, 1973; Mumford, 1979; Pettigrew, 1979; Storey, 1983; Thompson, 1983).

The organisation's existing structure, especially with regard to work organisation and job design, is another important factor influencing how new technology will be used. The examination of Job Design in Chapter Three revealed that not only will radical attempts to change existing structures and practices come up against organisational inertia, but, even where changes are made, if they are not compatible with existing methods and structures, they are likely to fail (Clegg and Fitter, 1981; Gough and Stiller, 1983; Pfeffer, 1981).

The size of the organisation also has to be taken into account. Whilst Contingency Theorists see size as a determinant of structure, this, as shown in Chapter 3, is by no means an indisputable assumption. Indeed, it may well be the case that size can be seen as a factor which limits, but does not determine, the choices available. In small organisations, it would not be possible to choose a structure based upon a high degree of specialisation and the extensive division of labour, whereas in a large organisation, this would be possible. However, within the limitations imposed by size, there do appear to be options open between those structural arrangements that are associated with Job Design and those associated with Scientific Management. This view would seem to be supported by the argument put forward in Chapter Three: that the relationship between size and structure is based upon preferred labour control systems (Child, 1984; Hendry, 1979 and 1980; Mansfield, 1984; Woodward, 1970).

It is also the case that existing technology, in that it is part of the existing structure that might need to be changed, can itself act to preclude options as to how the new technology can be used. The nature of the products being made is, obviously, also influential with regard to how the technology can be used. It has been pointed out that where small batches of products of high complexity are being manufactured, there is a tendency to use skilled labour; and where large volumes of simple products are made, the reverse can be the case. The reason for this appears to be that in the latter case, there will be less probability of problems occurring which need worker intervention in the production process than in the former case. Also, even where problems do arise, they are likely to be of a simpler nature than where complex products are being made, and so require less skill to remedy (Clegg, 1984; Hartmann et al, 1983; Warner, 1984; Williams and Steward, 1984; Williamson, 1973).

A key factor in promoting or retarding change is the organisation's profitability/performance. Whilst for most organisations this is largely a function of the state of the market, it is also dependent upon internal organisational efficiency; so it is possible for an organisation to be highly profitable in a depressed market, and vice versa. If an organisation sees itself doing significantly worse than its competitors, it may be driven to change its production methods radically in order to reduce its costs and become more profitable; British Leyland is a prime example of this. On the other hand, a market leader may adopt a policy of modernisation in order to maintain its advantage. However, the particular changes in work organisation in these situations are not dependent upon the level of profitability or performance as such, but upon the goals and strategy of the organisation - or, in some cases, the lack of them. These are also seen as being key in regard to other internal factors such as structure, size, technology and products.

All organisations, whether implicitly or explicitly, have goals. At the basic level, these may amount to no more than survival. owever, some organisations have sophisticated and well-thought-ut goals for growth and development. No matter how well-developed, r under-developed, the goals are, they will be pursued through a anagerial strategy which in turn may be explicit or implicit, well-thought-out and planned, or almost non-existent. It is in the setting of goals and, importantly, the strategy by which they are to be pursued that the organisation's culture will be apparent. Decisions that result in structures which are fragmented and dominated by tight control systems will show that Tayloristic values are at work, even though these may not be explicitly stated (Buchanan, 1984; Burawoy, 1979; Cooley, 1980 and 1983; Mansfield, 1984; Perrow, 1983; Storey, 1983; Thompson, 1983; Williams and Steward, 1984; Wood, 1979).

Goals and strategies have to be broken down and pursued through various levels of management who may or may not understand and sympathise; this aspect will be examined in the next section when looking at specific internal factors.

One final factor that affects the whole organisation needs to be taken into account: management-worker relations, or industrial relations. Where industrial relations are perceived as being poor or where management may feel they do not have the control over production that they should have, then new technology may be used to remove problem groups or reduce their power. Writers have cited a number of instances where, it is claimed, new technology has been introduced to reduce the power of recalcitrant workers.

On the other hand, management could choose to improve jobs in order to increase workers' satisfaction and reduce management-worker tension. The choice made would depend upon whether management had a particular strategy to cope with the introduction of new technology and upon the specific details of the situation. It would also depend upon whether or not workers were in a position to resist management decisions if they disagreed with them (CSE Micro-electronics Group, 1980; Friedman, 1978; Scarbrough, 1984; Shaiken, 1980; Wilkinson, 1982).

In looking at the general factors that may affect how new technology is used, it can be seen that whilst technical, structural and economic factors can play a significant role in limiting the choices available, they do not by any means determine it. A key factor is the organisation's philosophy/culture, which predisposes decision-makers to adopt, implicitly or explicitly, certain goals and strategies for the organisation's development, which in turn influence the way that new technology is used. However, strategies have to be applied to specific circumstances which themselves may produce counteracting forces.

In looking at the specific factors that relate to the decision-making process regarding new technology, the first one of note is the size and nature of the change envisaged. New technology which only affects one or two people in a specific area, has a low cost, and which could be operated in a manner similar to the old technology, may produce few problems, and the choices regarding its use may be obvious. On the other hand, the introduction of an organisation-wide computer-controlled production control system, which, at great expense, replaces a manual system, may affect a great number of people and radically change their work. In the former case, decisions may be left to local managers and supervisors. In the latter case, the decisions may be taken at the highest levels of the organisation (Pettigrew, 1973; Pfeffer, 1981; van Aken, 1978). Whatever the particular circumstances are, it would undoubtedly be the case that one department or sub-unit would bear the main brunt of the change; in the latter instance, it would be the Production Control Department, and the nature of that department would be important in terms of what choices were made.

The performance and importance of the sub-unit would affect decision-makers' perception of the change which could or should be made. If the sub-unit was deemed relatively unimportant, and its performance relatively good, then the decision on how to adopt new technology might be left to the managers in that area, who might, in an attempt to avoid problems for themselves, decide upon a policy of minimum disruption. On the other hand, if the sub-unit is seen to be central to the organisation's objectives and has a poor performance record, then higher management could decide to use new technology in such a way as to bring about radical change. If, in either case, cost reduction is an important factor, then a solution which would reduce the numbers employed and reduce, or not increase, the wages of those left, might well be attractive. This sort of solution would be compatible with a reduction of the skills required to perform the tasks involved (Buchanan, 1984; Child, 1984; Storey, 1983; Thompson, 1983).

Obviously, the existing structure of the sub-unit would be an important factor. In a department where jobs were already fragmented and which had a hierarchical authority structure, it might be very difficult, with the existing staff, to use new technology to increase skill and participation because of the low calibre of labour available. However, if workers were highly-skilled, they might be sufficiently well-organised to prevent any deterioration of their skills and conditions. In either case, the informal structures within the sub-unit would have to be taken into account. Whilst on paper some employees have little authority, in practice, they might be key personnel. Therefore, it is important to look beyond the formal structure in order to understand the forces at work (Buchanan, 1984; Burawoy, 1979; Purcell and Earl, 1977).

The management-worker relations within the sub-unit have also to be taken into account. Regardless of the organisation's general industrial relations climate and any strategy that exists across the organisation to cope with change, the relations within the particular area affected by change will be a factor that cannot be ignored by those charged with deciding how new technology in that area will be used (Buchanan, 1984; Storey, 1983; Thompson, 1983).

The penultimate factor, and one of the most important, in determining what choices are made, is the values, attitudes and self-interest of those involved in the decision-making process. It may well be that those involved share the values and attitudes of the organisation as a whole and, therefore, the outcome is likely to reproduce existing organisational arrangements with regard to the use of new technology. However, if the organisation is orientated to a Tayloristic approach and some of those involved have a more humanist-orientated approach, then the outcome might be different. A key factor in either case might be self-interest. If those involved see that particular types of change might work against their career prospects and status, then they would be likely to resist them. Therefore, in examining any change process, it is necessary to take into account individual and group values, attitudes and self-interest (Buchanan, 1984; Dickson, 1982; Gough and Stiller, 1983; Hedberg and Mumford, 1975; Jones, 1979; Perrow, 1983; Rosenbrock, 1981).

The last, and to some the most important, factor is the power relations between the various groups and individuals involved in the decision-making process. Here, formal authority should be distinguished from actual power. It may be the case that managers and supervisors have the formal responsibility for making decisions, but the power that workers can exercise through collective or individual action may force them to accede to their demands. Also, in the process of deciding upon a particular course of action, the information supplied to decision-makers is crucial, as this gives a great deal of latent power to those who are responsible for collecting and providing that information. These individuals have been called "technical gatekeepers" because they can control the gateways to information and thus exert considerable influence on the premises upon which decisions are taken. Therefore, in the end, those who can exert most power, regardless of the quality of the arguments and their formal level of influence, will carry the day (Bjorn-Andersen, 1983; Buchanan, 1984; Hickson and Butler, 1982; Perrow, 1983; Pettigrew, 1973; Pfeffer, 1981; Rose and Jones, 1983; Williams and Steward, 1984).

In looking at the specific internal factors that affect decision-making, it can be seen not only that they are complex, but that they can also be contradictory. However, as with the general factors within the organisation, it appears that whilst the technical, structural and economic factors may limit the choices available, they do not determine the actual outcome. It appears that the values, attitudes and self-interest of those involved push them to adopt certain positions, within the limits set by the other factors, and that the final decision depends upon a political process whereby groups and individuals bargain with, and lobby, others, to obtain their preferred outcome. The actual outcome will depend upon who can marshal the greatest support for their cause.

CONCLUSION: THE LIMITS OF CHOICE

In this, and previous, chapters, the argument has been developed that the impact of new technology is not something that is determined either by the characteristics of the technology itself or by a process of rational evaluation and decision-making in organisations that are closed and value-free, but, instead, by a range of external and internal factors (see fig. 1).

This view sees organisations as open systems which are affected not only by economic and technical forces within the ambient society, but also by its culture. This culture affects the organisation, in terms of its own culture/philosophy, and also the members of the organisation in terms of their values and attitudes.

Within the organisation, many factors, both internal and external, work to limit the choices that are available or which are seen

FACTORS WHICH AFFECT THE INTRODUCTION AND USE OF NEW TECHNOLOGY

	GENERAL	SPECIFIC
INTERNAL FACTORS	The organisation's history and development Its philosophy/culture Its structure Its size Its existing technology and products Its profitability/ performance Its goals and managerial strategy Its management-worker relations	The size and nature of the change Sub-unit performance and importance Sub-unit structure Management-worker relations within the sub-unit The values, attitudes and self-interest of those involved The power relations of the groups and individuals involved
EXTERNAL FACTORS	The nature of the political economy Culture Historical development Ideology Social institutions Political stability State of the economy State of technological development	Product market Labour market Availability of technology

Fig. 1

as acceptable when deciding how new technology will be used. However, these factors can conflict with each other, and therefore choices still have to be made; the final outcome is seen as depending upon the values, attitudes and self-interest of those involved and whether or not they can command the power or mobilise those with the power to support their favoured outcome. Therefore, choice does exist, albeit constrained, but the final outcome will depend upon who can gain most support in a given situation.

It follows from this that the impact of new technology will vary from organisation to organisation and maybe even within organisations.

However, it is possible to gain some indication of what that impact might be across society in Britain. Britain, as noted previously, has tended to adopt organisational practices which reflect Scientific Management precepts. It can be expected, at a time when profits and markets are depressed and unemployment is high, that managers will be predisposed to cut costs, especially labour costs, when introducing new technology, and that workers in general will have little opportunity to resist this tendency. It might then be expected that new technology will be used in such a way as to reduce workers' skill and control, to cut the numbers employed, and to cut wage costs. If this is so, then the impact of new technology will be to create low-skilled, low-motivated workers whose job satisfaction will be minimal. This, as argued in Chapter 3, may be inefficient for the organisation in the long term and will certainly be detrimental to workers' mental health.

However, as argued in this chapter, other factors are also at work, and the outcome of technical change, and the factors involved, can only be revealed by examining how particular organisations have coped and are coping with new technology. This is the reason for the importance of the nine case studies that have been carried out; they provide evidence from a wide range of organisations regarding the process and impact of technical change. Equally importantly, they also provide empirical data which can be used to evaluate the strengths and weaknesses of the organisation-specific aspects of the conceptual framework and show where it needs further development.

The case studies will be presented in Chapters 7 - 10, following a description in the next two chapters of the aims, objectives, and methodology of the research, and the specific technology being studied.

CHAPTER FIVE

AIMS, OBJECTIVES AND METHODOLOGY

INTRODUCTION

This research was based in the MRC/ESRC Social and Applied Psychology Unit at Sheffield University. However, the research project itself was a joint one between the Unit and Sheffield City Council's Employment Department. The research was jointly funded by the Economic and Social Research Council and the Employment Department.

The Social and Applied Psychology Unit was established by the Medical Research Council in 1968 to promote the application of psychology in work settings. In the last few years, the Unit has become involved in studying the impact of new technology on work; at the time that this research began, the Unit had been involved in evaluating the impact of computers in health care.

The Employment Department was established by Sheffield City Council in 1981 as a response to the growing level of unemployment in the city, which was then, and continues to be, above the national average. Part of the Department's remit was to examine the impact of new technology on employment levels and job quality in Sheffield.

In 1982, the Unit and the Employment Department agreed to set up a joint research project to examine "The Impact of New Technology on Work Organisation and Job Design". The research was undertaken by one post-graduate researcher, and was carried out between October 1982 and September 1985.

AIMS AND OBJECTIVES

The broad aim of the research is to examine the impact of new technology on work organisation and job design. This involves examining not only the outcome of the change process in particular organisational settings, but also the process of change itself. The intention is to develop a conceptual framework for the understanding of what happens when organisations adopt new technology, and how it happens. By so doing, it is hoped to promote the successful use of new technology. Successful, in these terms, is defined not only by an organisation's technical and financial criteria, but also by the needs of human beings for meaningful and fulfilling work. For this reason, in accordance with Job Design criteria, particular attention will be paid to the issues of skill, variety and control when examining the jobs and work organisation that accompany the introduction of new technology. Therefore, the main issues being investigated are:-

i) Why do organisations adopt new technology?
ii) How do they decide how to use new technology?
iii) What is the outcome in terms of the organisation's technical and financial objectives, and in terms of work organisation and job design?
iv) What alternative forms of use were considered/were available?

From the previous chapters, it is argued that a wide range of factors, both external and internal to the organisation, will affect the change process. The case studies can only, obviously, examine the internal factors, but it is hoped that by so doing, this will, indirectly, illuminate the influence of the external factors. Many of the external factors will affect all organisations and it is postulated that, for cultural, ideological and economic reasons, there would be a tendency in

Britain for new technology to be associated with Tayloristic methods of work organisation and job design. However, this would depend upon the particular product and labour market situation faced by individual organisations. With regard to internal factors, whilst some of these, such as size, structure and technology, are seen as limiting the choices available, others, especially individual beliefs and values and organisational culture, are seen as predisposing decision-makers to adopt particular solutions when faced with change. It is concluded that the final outcome would be related to the preferences of, and power wielded by, those involved rather than a rational assessment of the pros and cons of the situation.

Therefore, the influence of the following factors upon the change process also needs to be examined:-

i) The past history and development of the organisation, and its present structures and practices as they relate to work organisation and job design.

ii) The organisation's philosophy/culture as it relates to job design.

iii) The organisation's goals and managerial strategy that relate to new technology and its use.

iv) The relevant external and internal technical and economic factors and the perceived importance of these by those involved.

v) Who is included, and excluded, from involvement in the change process and their relative influence on the final outcome.

vi) The effect of the values, attitudes, self-interest, and power of those involved in the change process.

By examining these factors, it will be possible to illuminate more clearly the four issues involved in the change process that forms the subject of this research. This examination will also reveal the strengths and weaknesses of the conceptual framework presented in the last chapter and how this needs to be developed in order to have a more general understanding of the impact of new technology.

METHODOLOGY

Choice of Methods

In choosing research methods, the first decision to be made, and one that appears to be surrounded by some controversy, is whether to use large-scale quantitative or small-scale qualitative techniques (Fryer, 1984; Kulka, 1982). Both these approaches have their benefits, and also their drawbacks and criticisms.

Quantitative methods are usually used to test or verify a specific hypothesis. These methods involve the collection of data, using such devices as questionnaires, normally from large sample groups, the members of which are selected either at random or on the basis of particular characteristics: age, gender, profession, etc. These techniques lend themselves ideally to the carrying out of longitudinal studies of large samples of subjects, spread over a wide geographical area, in a relatively quick and cost-effective manner. The data collected is then subjected to analysis, using advanced statistical techniques, in order to prove or disprove the original hypothesis.

The strength of quantitative techniques is that they produce results which have been tested by widely-available, tried and tested statistical methods, normally based on large samples. This gives the results an objectivity and validity which is at the same time both hard to challenge and easy to replicate. This allows specific hypotheses to be tested and re-tested using the same or different data, and, therefore, for scientific theories to be built upon a recognised body of widely-tested work (Reichardt and Cook, 1978).

Despite the acknowledged benefits of quantitative methods, there are also criticisms of the applicability of these methods to real people in real situations. The first is that human beings and their environments are far less amenable to control, and far more complex, than those encountered in the laboratory. The second is that the statistical techniques themselves, in terms of such factors as how one measurement affects another, are not free from error. A final criticism, and probably the main one, is that whatever the precision and rigour employed, such techniques can create a false environment for those involved and, therefore, the results do not reflect how people behave in their normal everyday setting but rather they mirror the artificially-created world of the research design (Deutscher, 1970; Fryer, 1984; Payne, 1982).

Therefore, whilst quantitative techniques are a major and valuable tool of research, they are not free from serious criticism.

The alternative is to use qualitative methods. Such techniques are used, normally, to examine processes and situations in small-scale studies rather than to examine a specific hypothesis using a large sample. As with quantitative techniques, the aim is to contribute to the building and testing of scientific theory. However, this is done by attempting to describe and understand social situations through the use of such techniques as personnel interviews, observation and the collection of relevant documents.

These methods, it is claimed, capture the full richness and complexity of the real world in which people live and work. In particular, such techniques allow the researcher to understand and to show how, and why, individuals and groups act as they do (Fay, 1975; Van Maanen, 1979).

Therefore, qualitative methods avoid the main criticisms levelled at quantitative methods, in that they avoid the artificiality and the errors of statistical packages by the detailed examination of people and their actions in their normal environment.

Needless to say, qualitative techniques are also not free of serious criticisms. They are seen as being extremely subjective rather than objective; as lacking rigour and reliability in their approach; and the end product is rarely open to re-testing or reproduction by other researchers. Another criticism is that reports based on such research findings can tend to be presented in an idiosyncratic and individualistic manner, such that generalisations can be difficult to draw (Fryer, 1984).

Therefore, as with quantitative methods, qualitative methods have both their advantages and disadvantages.

As the above brief examination of the advantages and disadvantages of quantitative and qualitative methodologies shows, there is no such thing as the ideal methodology which is free from shortcomings or criticisms. This, perhaps, partly explains why the debate regarding the choice of methods has become the subject of controversy (Fryer, 1984).

Nevertheless, the researcher does have to make a choice regarding the research methods to use, though in so doing he or she must be aware of, and seek to overcome, the shortcomings of the particular investigative techniques they eventually decide to use (McGrath, 1982).

However, Campbell and Stanley (1966) and Payne (1982) have suggested a different approach to the choice of methods. This is an approach based not upon the merits and demerits of particular methodologies as such, but upon the subject to be studied. They point to the need for researchers to have a thorough understanding of the aims and objectives of their research before deciding upon the tools to be used to carry out the research. Only when this is done is the researcher, they believe, in a position to decide upon the methods to be used. This is because they consider that the need to adopt different research strategies depends upon the type of research being undertaken and the issues involved.

They argue that there should be an appreciation that whilst some studies, where large samples are available and specific issues, based upon a sound body of knowledge, are to be tested, lend themselves to quantitative techniques, others do not. Where only small samples are available, where the body of knowledge about the subject is small and disputed, and where a process, rather than a specific hypothesis, is being examined, then qualitative techniques will be best suited.

Taking this view, it is possible to see quantitative and qualitative techniques not as being mutually exclusive, but as being inter-related. The latter can be used to explore particular situations where the issues may not be clear and where there is a need to create a body of empirical evidence. On the other hand, quantitative methods can be used to test particular hypotheses once such a body of empirical evidence has been established.

The converse can also apply. Qualitative techniques can be used to examine in greater detail and richness the results of quant-itative research. Indeed, by taking this view - that quantitative and qualitative techniques are ways of focussing upon different aspects of the same problem - it is possible to envisage research strategies which incorporate both types of methodology.

However, this research was carried out using qualitative techniques. This was for three reasons.

Firstly, despite the number of articles published in the area of new technology, there have been few studies, or had been when the research began, which had rigorously examined both the outcome of the introduction of new technology and the process by which the outcome was reached. Indeed, much of the literature was, and still is, speculative and based either upon very limited studies or upon secondary sources.

Therefore, one of the purposes of the research was to find out what changes were taking place where new technology had been introduced, and to build up, through a case study approach, a body of knowledge which, together with other studies that have been and are being undertaken, will form the basis for future quantitative studies.

Secondly, whilst there has been much talk of new technology, there were still, when this research began, only a relatively small number of organisations both locally and nationally that had adopted it, and even in these, only a few people were affected by its introduction. Therefore, the sample being studied was small, and it also proved very difficult to find organisations that were at the same stage of development for comparison purposes. Even when suitable organisations were located, it was not always the case that they were willing to co-operate with the research.

Lastly, the research was interested just as much in the process of change as in the outcome, and was therefore not seeking to test specific hypotheses.

For these reasons, it was decided that qualitative techniques were the most appropriate methods of research in this instance. However, regardless of the methods used, the research must show a rigour in both its design and execution in order to demonstrate its validity.

THE RESEARCH DESIGN

The Industry to be studied

As mentioned in the introduction to this chapter, the research was based in Sheffield and was partly sponsored by Sheffield City Council. Sheffield is famous for its steel and engineering industries, both of which have been heavily hit by the recession. Nevertheless, whilst it has a growing service sector, these two industries are still crucial to Sheffield's future prosperity.

In choosing the type of organisations to study, there were two guiding principles:-

i) For consistency and to avoid differences between industries and sectors, the organisations chosen should be from the same industry.

ii) The industry chosen should be one that is important to the local *economy of Sheffield.*

In terms of Sheffield, the industry had to be either steel or engineering. For two main reasons, the engineering industry was chosen. Firstly, the steel industry was still suffering the effects of the bitter 1979/1980 strike, and it was anticipated that problems of access and co-operation might arise. Secondly, the researcher had spent 11 years working in the Sheffield engineering industry, and it was logical to take advantage of his experience in the industry.

Therefore, organisations in the Sheffield engineering industry were chosen for the research, although two companies in Rotherham were also included because of their suitability.

The New Technology to be studied

The choice of technology to be studied was guided by three principles:-

i) For consistency and accuracy of comparison, the technology to be studied should be similar in all organisations.

It should be a form of new technology that was present in sufficient numbers to allow the research to be properly carried out.

iii) It was likely to have a significant effect on the engineering industry.

In the event, the choice was relatively easy: it was decided to examine the introduction of Computer Numerically Controlled Machine Tools (CNC). The technology itself and its development will be described in the next chapter, but it was chosen for three reasons:-

i) Since the emergence of CNC in the early 1970s, there has been a rapid growth in its use: by 1981, CNC accounted for, by value, one-third of all machine tool sales in Great Britain (Rodger and Bruce, 1983); although, even so, CNCs still only constitute 3.32% of all machine tools in Britain (Metal Working Production, 1983).

ii) It appears to be the only form of new technology that has penetrated the shopfloor in all sizes of engineering companies, from the very large to the very small.

iii) Beyond its immediate impact, it may bring about a radical transformation in engineering. This is because by linking individual CNCs together by transfer devices such as robots and by controlling them through a central computer, they form a Flexible Manufacturing System - the so-called "Peopleless Factory".

For these three reasons, CNC is a significant development which has important implications for the future of the engineering industry, and is therefore worthy of study.

The Choice of Organisations

In selecting organisations that might be suitable for study, the main objective was to examine, over a period of time, the introduction of CNC into different organisational settings. This was to establish if (a) there were different approaches to its use, and (b) what factors were influential in the selection of these approaches.

It was decided to select the engineering companies on the basis of size and product. The reasons for the use of these two reference points was that size, as argued in Chapters 3 and 4, is seen as a constraint on the type of organisational structure that can be achieved. In small companies, it is not possible to divide labour and fragment skills in the same way that could be achieved in larger organisations. Consequently, it might be expected that CNC would be used in a different way in small companies than in large ones. The argument is similar with regard to product; as pointed out in Chapter 4, small batches of complex products are likely to require more operator intervention and skill than large batches of simple products. It is usually the case that there is an inverse relationship between batch size and complexity, i.e. the larger the batch size, the more likely it is that the product is a simple one. The supposition in the case of both size and product is not that these factors determine what takes place, but that they act as a constraint upon choice. Therefore, as an alternative to selecting companies merely at random, it was decided to use these two factors as guides to the selection process. They also have the added benefit of being information that can quickly and easily be obtained from companies, which makes the process of deciding whether or not a company is suitable for study relatively simple.

In choosing organisations, two other factors were taken into account. The first was the need not just to compare different-sized companies with different product, but also the need to compare like companies, companies of a similar size and similar products. Therefore, pairs of companies, matched by size and product, were chosen. The second factor was the limited time and resources available. Only one researcher was involved and the research was limited to three years' duration, including writing up. Based on the experience of others, it appeared that ten case studies would be the maximum number to undertake in the circumstances.

For these reasons, size, product, the need to "pair" companies and the limit of ten studies, it was decided to select the companies on the following basis:-

Two large companies manufacturing large batches;
Two large companies manufacturing small batches;
Two medium-sized companies manufacturing medium batches;
Two small companies manufacturing large batches;
Two small companies manufacturing small batches.

In this instance, large companies are defined as those employing 500 or more on the same site, small as employing less than 100, and medium as between 100 - 500 employees. A similar division is made with regard to batch size and complexity: small batches are those of 100 or less; medium between 100 and 300; and large are 300 plus. These divisions were chosen because CNC is designed to produce batches ranging from 1 to 300/400 (De Barr, 1978).

When the process of contacting, and obtaining the co-operation of, companies began, it became apparent that some modification of this design would be needed. In the end, 9 companies were included in the sample on the following basis:-

Two large companies manufacturing large batches;
Three medium companies manufacturing medium batches;
Two small companies manufacturing large batches;
Two small companies manufacturing small batches.

The two changes - the exclusion of large companies with small batches and the inclusion of 3 medium-sized companies - were for the following reasons.

It proved impossible, at least in South Yorkshire, to find two large companies that manufactured small batches using CNC. Therefore, this objective was excluded from the study.

The reason for the inclusion of three medium-sized companies in the survey relates to a problem faced by all field workers - that of maintaining access. In this case, one of the medium-sized companies allowed some interviews but then decided it did not wish to have any further involvement, the reason given being that they were too busy. This left the problem of only having "half" a study. Rather than complete the project with studies in just 1½ medium-sized companies, it was decided to seek out a further company in this area. Therefore, three studies of medium-sized companies were carried out, though one, whilst being of interest, was incomplete.

Another problem that emerged when the fieldwork began revolved around the question of batch size. In practice, the companies concerned manufactured a range of batch sizes, and whilst it was possible to say that some companies made small batches and some large, there was a degree of overlap. Nevertheless, as will be demonstrated in the case studies, batch size and complexity is a useful way of differentiating between companies.

There was one final problem that arose when seeking suitable companies, which was to find ones where it was possible to study the introduction of CNC in a situation that allowed "before and after" comparisons. Whilst it did not prove easy to locate companies that were already using CNC, it proved extremely difficult to find companies that not only were contemplating buying CNC, and introducing them in the period the research was being undertaken, but would also allow access. For these reasons, before, during and after studies were only carried out in two of the nine companies, and in the other seven cases, CNC was already in use when the studies began.

Not only does this prove the need to use flexible research techniques when field research is involved, but it also proved a blessing in disguise. The reason, as the studies will show, is that firms can and do change their CNC organisation over time, rather than adopting a once-and-for-all system of working. Therefore, the process of change can be slow and certainly covers a longer period than the one encompassed by this study.
By looking at companies at different stages in their use of CNC, a much fuller picture of the change process was obtained than would have been the case if all the studies had been of the "before and after" variety.

All this, of course, shows that there is a world of difference between designing research in theory and carrying out research in the field. This highlights the need not only for a degree of flexibility in the research design and methods, but also in the researcher.

RESEARCH METHODS

The primary methods of research were:-

i) Interviews with the various managers, workers, trade unionists;
ii) Observation of working methods and practices, and discussion of these with those in the organisation, either at the time or subsequently;
iii) Examination of relevant company documents;
iv) Observation of meetings relevant to the process of change;
v) Discussion with parties outside the organisations who had been involved in some way in the change process.

Whilst it was always obvious that interviews with those involved would provide the bulk of information, there was no clear and obvious preference for any of the methods of data collection, and the original intention was to use all the methods to the fullest extent. Of course, this was not always possible in all cases for a variety of reasons, and whatever source of information that was available was considered.

The Problems of Access

The problem of negotiating and gaining access is one that all researchers face and encounter problems with (Kulka, 1982).

However, even before that stage, there is the need to identify suitable organisations. If the criteria are very broad, then the problem is reduced, but if, as in this case, organisations with particular characteristics relating to technology, size and product are required, then this can prove a difficult task. Fortunately, the problem was less than might otherwise have been the case because the researcher was given access to a survey of new technology in Sheffield that had been carried out in 1981 by Sheffield City Polytechnic. This indicated organisations that were using CNC and a few which were planning to use CNC. Other information on CNC users was supplied by people in some of the organisations studied, and the local SkillCentre was also very helpful in this respect.

However, as mentioned earlier, finding companies who were buying CNC but had not yet installed it was extremely difficult. Even when this criterion was set aside, it was still difficult to find appropriate organisations. This is demonstrated by the fact that it took 18 months to locate and gain access to nine companies, and even so, it proved impossible to find large companies that manufactured small batches of components using CNC. In a number of cases, contact was made, by mistake, with companies that did not have, and had no intention of getting, CNC. Only in two cases did companies actually refuse access, but in both cases it took them over 3 months to do so, which was not only frustrating but also time-consuming. In only one case did a company allow access and then change their mind. Even where access and full co-operation were gained, this could be a slow process.

Nevertheless, the researcher was struck, in most cases, by the friendliness and helpfulness of those involved.

The Duration of the Case Studies

In all cases, except the one medium-sized firm already mentioned, the studies were longitudinal, covering events over a period of time, rather than "snapshots" at particular moments in time. The entire fieldwork covered a period of 28 months. However, given that it was possible neither to carry out nine studies at once, because of time constraints, nor to find nine companies willing to co-operate at the start of the research, the initial approaches to, and first round of interviews with, the companies were spread over an 18-month period.

The second visits, in the main, were at 3 or 4 month intervals, though this might be longer depending upon the circumstances. In one company, for example, a revisit was arranged to coincide with the arrival of an additional CNC. This had been due to take place in July 1984, but the machine was not delivered until November 1984. In other instances, return visits were delayed due to sickness, holidays or even companies being "rushed off our feet at the moment".

The number of return visits made to each company varied depending upon when the first contact was made, and what changes were taking place. In one company, the first visit was made in January 1983 and regular visits thereafter until February 1985; in other cases, the time between the first and last visit was very much shorter.

In all the companies, even those where the technology had been installed for some time, changes in the organisation of work were taking place. In no instance could the situation be described as static, though in some the changes were small. This shows the folly of seeing organisations, particularly in the present uncertain economic climate, as static and unchanging. It also shows the need for longitudinal studies that last longer than two or three years, if the full effects of the change process are to be examined.

The Efficacy of the Research Methods

In terms of the efficacy of the various research methods, interviews, as anticipated, proved to be the major source of data. Most of these were tape-recorded, though in some cases this was not possible. Whilst all the interviews were carried out using semi-structured interview schedules, after the initial interviews, when trust had been built up, the interviewees became more relaxed and open, in most instances at least, and they came to resemble conversations rather than interviews. (See Appendix for questions).

For the most part, once initial access was established, the case studies involved making contact with a particular manager, who, after being interviewed, would arrange interviews to take place with other managers and workers.

In the first instance, interviews with managers were used to establish the background of the company - size, product, market, management structure, etc. - and to gain the "official" account of the change process. Subsequent interviews and meetings would then focus upon specific aspects of the process as they related to the person involved. In this way, important events within the organisations came to light, and specific issues could then be followed up in detail with the various interested parties.

This allowed a picture of events to be built up, showing what had actually happened or was happening, as averse to the "official" account.

In some cases, the researcher was given a free hand as to whom to interview and when. In other cases, certain managers insisted that they approve all arrangements for interviews. There were some instances where workers expressed the view that future interviews should take place outside the company, because they felt constrained by the proximity of managers and supervisors.

In some instances, difficulties were encountered, but in most cases these were overcome. In one company, for example, it proved difficult to obtain permission to interview one of the key people. The Managing Director explained that the individual concerned was "very busy and cannot be spared to speak to you". In the event, this problem was overcome when it was discovered that the person lived in the same street as the researcher, and that they had been on "nodding terms" for some time! Therefore, the interview was carried out at his home one evening.

One problem encountered in the medium-sized and large companies was access to senior managers. There was a tendency for their subordinates to "protect" them from the researcher. Nevertheless, in the main, people were surprisingly open, and access to those involved was not denied.

Observation also proved a useful method of gathering information. Observing the working methods in each company was often the easiest and most revealing method of coming to terms with the specific nature of the work that people do. On paper, the difference between a machine cycle time of one minute and one of three minutes may not seem significant; in practice, it can be the difference between a gruelling and monotonous job and one where the machinist is able to exert some control over what he does and gains a degree of satisfaction from it. However, the freedom to observe varied from company to company. In some cases, the researcher was given a completely free hand, whereas in others, his presence was regarded as a potential distraction to production by management. Nevertheless, observation proved a valuable and revealing research tool.

The examination of documents, on the other hand, proved less helpful. Whilst in one or two instances, they were of interest, in most cases they were notable for what they did not show rather than for what they did. Written justifications for machine purchase, for example, were often highly technical and lengthy but omitted key factors. They would compare CNC with the existing method of production, but gave no indication of why CNC was chosen in place of any other alternative in existence. The documents were prepared on the basis that CNC was the only option, but no evidence for this was given. Neither did the documents compare the benefits of different methods of using CNC. It was assumed that the method specified was the best or only way, but once again, there would be no justification for this.

In small companies, there tended to be no written justification at all, and in some other companies, documents were "not available to outsiders". In any case, as mentioned, little could be gained from their contents.

Observation of meetings also proved less useful than anticipated. In most cases, key decisions were not taken in "formal" meetings but in "informal" discussions that could take place at any time and anywhere. In the large companies, it was sometimes impossible, even for some of the managers involved, to know when, how, and by whom a particular decision had been made. In the smaller companies perhaps only one or two people might be involved in taking decisions and even informal meetings might not take place. Whilst this information, or rather lack of it, is informative in revealing how organisations operate, it is not so revealing in establishing the basis on which particular decisions were taken.

On the other hand, discussions with parties outside the organisation in question, when these were possible, did on one or two occasions prove interesting. One technical consultant revealed that he was puzzled as to why one organisation had bought CNC in the first place; whilst in another instance, comments on the managerial and organisational style of one company proved accurate and illuminating.

Nevertheless, despite the shortcomings of some of the methods used, together they did allow a picture of each organisation to be built up, describing why CNC was bought and used and how the process developed, which the researcher believes is both accurate and a valuable contribution to the knowledge in this area.

THE PROBLEM OF EGRESS

Whilst access, as mentioned earlier, is a common problem for researchers, egress - when to finish the research - can also prove difficult.

There is always the temptation, especially when something interesting is happening, to do one more interview or make one more visit. Yet a researcher has only a limited amount of time in total and for each organisation, and even the most friendly company can run out of patience. The ability to recognise when a welcome has been exhausted is invaluable, even if in some cases the knowledge must be ignored. The decision to spend more time in one company than another is a matter of judgment and can only be justified by the final results. Yet, in some cases, either where the organisation is large and many people are involved, or the events do not fall into the time allocated, more time has to be set aside.

Therefore, inevitably in this type of research, some studies are longer than others, but hopefully the nine case studies do justify the time spent on them.

CHAPTER SIX

COMPUTER NUMERICALLY CONTROLLED MACHINE TOOLS (CNC)

INTRODUCTION

This chapter will describe Computer Numerically Controlled machine tools (CNC), their function, their development and their implications for job design and work organisation. It will also examine five studies of CNC. It is argued that existing studies of CNC usage have produced partial explanations of the factors which influence their use, but which, whilst drawing attention to important issues, ignore other significant factors. The chapter will conclude that CNC is not a deterministic technology and that there is significant scope for the exercise of choice in how it is used.

THE ADVANTAGES OF CNC

CNC machine tools are computer-controlled devices for cutting and shaping pieces of cast or rolled metal. The three most common types of CNC are turning lathes - machines for producing circular components; milling machines - for removing material from flat surfaces; and machining centres - which are similar to, but far more complex than, milling machines. In 1976, there were 9,725 CNCs in Britain; by 1982, the figure was 25,802 and sales were increasing rapidly (Metal Working Production, 1983).

CNC has become so popular because for the first time it allows the automation of small batch production of engineering components. This is significant because 75% of all machining operations involve small to medium batches, and 40% of those employed in manufacturing are involved in their production (De Barr, 1978). Traditionally, batch production has been carried out on two types of machine tool:-

i) Conventional machine tools controlled manually by a skilled or semi-skilled machinist. These machines have the advantage that they are very flexible, but they are also slow, the quality is variable, it is difficult to machine complex shapes on them, and they often need expensive jigs, to guide the tool, and fixtures, to hold the work. For these reasons, they tend to be used on small batches.

ii) Automatic machine tools which are controlled by some form of pre-set mechanical or electro-mechanical arrangements. Their advantage is that they are fast and consistent, but they are inflexible - limited to performing a narrow range of machining operations, slow to set up, and only economic on larger batches of components.

In the past, the cost advantage for small batches has been with conventional machine tools and for larger batches with automatic machines. The intermediate ranges have been done on either, depending on the complexity of the products involved. With CNC, this has changed; its proponents argue that batches between 5 and 300 - 400 are more economically produced on CNC; this is especially the case where complex components are involved (De Barr, 1978). This is because it combines the best of both types of machine: it is flexible, fast, consistent in quality, faster to set up than automatic machines, capable of machining complex shapes, and rarely needing expensive jigs and fixtures. They are, however, considerably more expensive than most conventional and many automatic machine tools; nevertheless, their flexibility and productivity have accounted for the rapid growth in the sales of these machines.

THE ORGANISATION OF WORK AROUND CNC

On a CNC machine tool, the cutting cycle, from the beginning of the cutting process on each component to its completion, is controlled by the computer - it is automatic. However, whilst the CNC eliminates the need for human intervention whilst the machine is cutting, it is required at five points during the production process:-

i) Programming the machine: each batch of components has to have a separate program. Therefore, someone has to decide upon methods and tooling, select speeds and feeds, and calculate and write the program. The program is then usually encoded onto a punched-paper tape which allows it to be fed into the CNC;

ii) Setting up the machine: this involves positioning the tools and, if they are required, arranging jigs and fixtures;

iii) Proving out (editing) the program: programs are rarely 100% correct and they need to be checked out, and amended if necessary, on the machine. This usually involves producing the first component of a batch in order to check its accuracy;

iv) Loading the raw material into the machine and removing the finished component;

v) Machine optimisation: this involves inspecting the finished components for accuracy and making adjustments during a production run to compensate for tool wear or material variability.

There is nothing inherent in the technology that determines who does these tasks. One person could do them all, or they could be split up amongst a number of people: all could be done by shopfloor personnel or some could be done by staff specialists.

In practice, as Wall et al (1984) have pointed out, there are at least five different methods of organising work around CNC:

i) A programmer, usually a member of staff such as a production/methods engineer, will prepare the tape; a setter will set up the machine and prove the tape; and an operator will run the machine, basically loading and unloading it.

ii) A programmer can prepare and prove the tape, leaving the operator a non-programming setting and operating role.

iii) A setter can prepare and prove the tape and set up the machine, leaving the operator to load and unload.

iv) A programmer can prepare the tape and the operator will prove it, set up and operate the machine.

v) An operator can prepare and prove the tape, set up the machine and run it.

The first three methods have the potential to create boring and monotonous jobs for operators which require little skill, the main function being to load and unload the machine and to monitor its performance. On the other hand, programmers and setters have more interesting and varied jobs. The fourth method would eliminate the need for a setter and give these functions to the operator, whose job would become more skilled and interesting. The fifth method would be ideal from the operator's point of view, in that it fulfils all the criteria of Job Design regarding variety, skill, autonomy and task completeness.

Despite the potential of CNC to create good or bad jobs, there has been a tendency to see CNC as a development which will transfer skills and control from the machine operator on the shopfloor to staff specialists (Hearn, 1978; Noble, 1979; Shaiken, 1980).

To see why this should be so, it is necessary to examine the development of machine tools and especially the forerunner of CNC, Numerical Control (NC), and the implication of these for shopfloor jobs.

THE MACHINIST AND THE DEVELOPMENT OF MACHINE TOOLS

The most common form of machine is still the general purpose conventional machine tool operated by a skilled or semi-skilled machinist. The machinist, using his knowledge, experience and the machine, translates the information on a drawing or methods sheet into a finished component. He transmits his purpose to the machine by means of the cranks, levers and handles that control the machine. Feedback is achieved through the hands, ears and eyes of the machinist, which tell him if something is wrong, and his knowledge and experience tell him how to correct it. Traditionally, the machinist's skill is learnt on the job over a period of years. It involves not only machining the product, but also the planning involved in setting up the machine, selecting tools, and deciding upon speeds and feeds.

In addition to his skills on the machine, the machinist can also play a role - usually unacknowledged - in the design process, in that he can be consulted by designers about whether or not their design can actually be manufactured, and if not, what changes are necessary. Therefore, the skilled machinist plays an important role in the production process.

The control that machinists have over the pace and quality of production has always been a contentious issue with managers, as was pointed out in Chapter 2. It should be remembered that Frederick Taylor, the founder of Scientific Management, was originally motivated by the desire to reduce the machinist's ability to control production.

Even before Taylor, and certainly after him, there have been attempts to reduce the importance of machinists. Changes in machine tool design and the increasing division of labour have meant that many machines and machinists have become restricted to a narrow range of functions. This in turn has reduced the need for skilled machinists and created a large body of semi-skilled machinists instead. In the case of automatic machines, the operator has been virtually eliminated altogether, though a skilled setter is required to set up the machine.

Nevertheless, given that 75% of all machined components are in the small to medium batch range, machinists, especially those involved in the manufacture of complex or varied components, still play an important role in the production process, and still have the potential to control the pace and quality of production (Buchanan and Boddy, 1983; Cooley, 1983; Noble, 1979; Shaiken, 1980).

However, the development of Numerical Control threatened once and for all to eliminate the machinist as a significant figure in the production process.

Numerical Control (NC)

Numerical Control, like CNC, is the control of a machine tool by a punched-paper tape on which instructions are encoded in alpha-numeric (hence numerical control) characters. However, unlike CNC, the NC machines did not have computers built into them, which, as will be explained below, was a significant factor in inhibiting their usefulness and sales.

NC was invented after the Second World War and its development was aided by two factors. The first was the developments in control technology which had taken place during the War and which made NC technically feasible. The second was the need by the United States Air Force (USAF) for machines capable of manufacturing, to high standards of quality, the complex parts required for the production of their aircraft. If the former made NC technically feasible, the latter made it financially feasible, because between 1949 and 1959 the USAF invested $62 million in its development. In addition to this, they paid for its installation in the factories of their leading component suppliers and specified that NC should be used in machining the components they were being supplied with. This meant that those companies involved in supplying parts to the USAF, and the machine tool builders who supplied machines to these companies, had to adopt NC or risk being excluded from the lucrative defence market (Jones, 1983; Noble, 1979; Tipton, 1980).

However, NC was by no means the only answer to the USAF's problems; there was at least one other alternative - Record Playback. This was a system whereby a machinist would make the first component in a batch and, during this operation, the machine's movements would be recorded on a magnetic tape. The rest of the batch could then be manufactured without the machinist by playing back the tape. Tape production for NC machines was, on the other hand, more difficult. This was for two reasons:-

i) Tape production, even for simple components, was very slow and difficult. For complex components, the aid of a mainframe computer would be necessary for the complex calculations involved;

ii) Even when the tape programs were made, they still needed proving out on the machine. However, if there were any faults with the tape, they could not be altered on the machine; the tape had to be removed from the machine and returned to the programmer. Therefore, proving the tape could also be slow and difficult.

Record Playback, on the other hand, did not have these problems: there was no need for complex calculations or for computers, the machinist made the component as on a conventional machine and by so doing an accurate tape was produced. Nevertheless, the USAF opted for NC.

Noble (1979), who has studied NC development, argues that the preference for NC rather than Record Playback was because it dispensed with the need for skilled machinists. He points out that this was a period when the aircraft industry was becoming increasingly unionised, especially amongst skilled machinists. This led to some long and bitter industrial disputes and to the consequent disruption of production and delivery. The USAF believed that the only way to ensure that their supplies of components were delivered on time and to specification was to remove control of the production process from machinists and place it in the hands of managers. The use of NC was seen to do this, whilst Record Playback was believed actually to increase the reliance on skilled machinists.

It is certainly the case that discussion of and publicity for NC stressed the importance of management control:

> . . . with modern automatic controls the production pace is set by the machine, not the operator. (Stickell, 1960, p61)

> The important decisions that affect unit cost, delivery dates, and product quality are, with N/C, in the hands of managers and professional employees, not the operator. (Howick, 1965, p105)

Therefore NC was chosen by the USAF, by their suppliers and by the machine tool industry. However, the problems with tape production and proving, especially the need for access to a mainframe computer, meant that the market for NC was limited, and in the main was restricted to the aerospace industry. Whilst this was not a problem for the USAF, it was for the machine tool builders, who wanted a product that could be sold to a wider market. They began, in the 1960s, to experiment with the use of computers linked to the NC machines to overcome some of these problems, but the size and cost of computers made this problematic.

The birth of CNC

It was not until the advent of cheap microprocessors in the early 1970s that it became technically and economically feasible to build computers into Numerically Controlled machine tools and thus to create Computer Numerically Controlled machine tools. However, once this was achieved, it overcame many of the problems of NC:

i) It made programming much easier: the computer could automatically perform many of the complex calculations that had slowed the process down before;

ii) The computer also allowed errors in the program to be amended on the machine, thus eliminating the need to take the tape back to the programmer to be altered.

Indeed, some CNCs now have a Manual Data Input (MDI) facility which allows the component specifications to be keyed straight into the machine without having to encode the program onto a tape first.

This meant that the potental market for CNC was much wider than was the case with NC. From the mid-1970s onwards, sales of CNC have grown rapidly whilst sales of conventional machines have fallen. The aerospace industry is still the largest single user of CNC, but the next largest users are small contract engineering companies who find the speed and flexibility of CNC ideal for their needs (De Barr, 1978; Metal Working Production, 1983; Tipton, 1980).

However, the development of CNC has once again raised the issue of operator control. For, if programming is easier and if both proving and programming can be carried out on the machine, then why cannot these functions be carried out by machine operators?

The heritage of NC has given CNC a reputation as a device for controlling and deskilling workers (Hearn, 1978; Noble, 1979; Shaiken, 1979). Yet, as the next section, which reviews five studies of CNC, will show, the organisation of work around CNC is not dependent upon the characteristics of the technology, but is dependent upon a range of other factors.

FIVE STUDIES OF CNC

In the last few years, CNC, like other forms of new technology, has been the subject of much discussion. Of the academic studies that have appeared, some are speculative, some are based on secondary sources, and of those where first-hand accounts are presented, the majority are based upon short visits to only one organisation. However, there are a few cases where more detailed studies have been carried out, but in only one instance, Sorge et al (1983), does there appear to be a study that covers a substantial number of different organisations.

This section will briefly look at a sample of five studies that have examined CNC. The most detailed of these studies, Sorge et al (1983), covers the use of CNC in Britain and West Germany. Three others, Black (1983), Clegg et al (1984), and Wilkinson (1983), cover Britain only, and the final one, Shaiken (1979 and 1980), examines the American experience of CNC.

Sorge et al (1983)

This is by far the most comprehensive of the studies, and covers the use of CNC in 6 British and 6 West German companies. The researchers, as in the present study, selected organisations on the basis of company/plant size and batch size. They examined the use of CNC within and between companies, and in particular they were interested in the factors which affected how it was used. The studies were not longitudinal and they were concerned neither with factors such as individual values and attitudes nor with power relations within the organisation.

The findings:

Their findings were that the use of CNC was dependent upon plant size, batch size, and socio-technical traditions specific to companies, branches of industry and nations. They argued that these factors combine to determine the form of CNC use within organisations.

Between Britain and West Germany, the main organisational differences that were found related to the degree of fragmentation, or differentiation, of tasks and functions. In Britain, there was a pronounced trend towards programming-related tasks being carried out by staff specialists, and even amongst these specialists, planning and programming was split between different groups. In West German companies, on the other hand, these functions tended to be integrated amongst groups of operators, planners, production engineers and managers, and chargehands and foremen. This resulted in a blurring of white collar and blue collar functions, greater flexibility, and more shopfloor programming.

With regard to plant size, it was found that in both countries, as plant size increased, so did fragmentation of tasks and functions. This trend was compounded by increasing batch size; as production batches became longer, the trend was to employ specialist operators, setters and programmers. In smaller companies, with smaller production runs, the tendency was for more integration of these functions and for more shopfloor involvement in programming. However, as mentioned, in West Germany, societal trends meant that even in large plants with large production runs, the tendency was towards less fragmentation and greater shopfloor involvement.

In Britain, the reverse was the case: fragmentation of tasks and functions was observed even in small companies with small production runs.

Black (1983)

This study is unique amongst those being examined in that it was carried out by a senior manager in the organisation concerned. The study traces the history of NC and CNC introduction and usage from 1966 through to 1980. The company, in 1980, employed 2,500 people and had 26 CNCs, some 6% of its total machine tool stock, which produced a wide range of components. The main aim of the research was to examine management objectives in introducing CNC. Issues such as company size, batch size, individual and group values, etc., are not examined.

The findings:

Black found that the main managerial objectives in introducing CNC were to:-

i) reduce human error and improve quality;

ii) respond more quickly to market conditions;

iii) reduce production costs;

iv) transfer control of production from machinists to managers;

v) replace obsolescent equipment.

That these objectives were, to a large extent, successful is shown by the organisation of work around CNC. In terms of costs, the 26 CNCs are said to do the same amount of work as 104 conventional machines, and though machinists' pay is still the same, they have to operate two machines at once instead of the previous arrangement of one man to one machine.

In terms of greater management control, this has been achieved by creating a new staff department which is responsible for programming-related functions. This not only guarantees management control over the production rate, but has, in Black's view, effectively deskilled the machine operators. Other objectives with regard to increased quality and decreased human error have also been met.

Clegg et al (1984)

This study examined the use of CNC in two British companies, both of which manufacture small batches of complex components for the aerospace industry. One of the companies employed 150 people, and had over 40 CNCs, whilst the other had above 1,000 employees and also had a large number of CNCs. The researchers spent nearly 12 months, on and off, in the smaller of the companies, but only paid a small number of visits to the other company. They were especially interested in the impact of structure and the organisation's guiding values, but other issues concerned with societal values, individual and group self-interest, and batch size were not examined.

<u>The findings</u>:

They found that the two companies used CNC in quite different ways. The large company had a rigid division of labour around CNC: the machine operators were in fact "machine minders"; the setting functions were carried out by a separate group of shopfloor workers; and programming-related functions were the preserve of a specialist programming department.

The smaller company, on the other hand, had a more integrated and flexible approach: the operators were expected not only to set up and monitor the machine, but also to prove tapes and in some cases to program as well. There were also staff programmers, but these worked in co-operation with the operators and tended to concentrate on the longer, more complex, jobs.

The researchers believe that the difference in CNC usage reflected the different nature of the two companies. The smaller is an informally-managed company with a high level of trust and a relatively unsophisticated management control system. The large company is bureaucratically structured, with a tight control system and a history of fragmentation and specialisation.

Clegg et al argue that the "techno-social logic" of each firm determined the organisation of work around CNC. By this, they mean that the organisation's guiding values, which reflect its history and culture, and its structure are the key factors. These determine what sort of structures and relationships will succeed in each organisation. In the smaller organisation, both its structure and values would militate against fragmentation of functions and rigid control, whilst in the larger company they would favour such arrangements.

<u>Wilkinson (1983)</u>

This study examined CNC usage in a machine tool manufacturing company. The company is owned by an American corporation but has a high degree of internal autonomy; however, continuing losses, which had brought about a large number of redundancies in previous years, led the parent company to replace the senior management team, and a new one had just taken over. At the time of the study, the company employed 550 workers, and had 5 CNC machines, which were used to produce a variety of parts in small to medium batches. The study concentrates on the "politics" of change, but does not examine factors such as plant and batch size, organisational values, etc.

<u>The findings</u>:

The organisation of work around CNC is highly flexible, though not uncontentious. On one CNC, the operator performs all the functions from loading and unloading through to programming. On three of the machines, the operators carry out some 60% of the programming, and on the fifth machine, the operator rarely programmes but often proves the programs. There is also a separate group of staff programmers.

The level of shopfloor programming appears to depend to a large extent upon the preferences of individual operators, whose programming skills are largely self-taught, as to how much responsibility for programming they wish to have. However, shopfloor involvement in programming was supported by supervisors, foremen and middle management, who saw the system as efficient and flexible and who sympathised with the desire of operators to retain and increase their skills.

The staff programmers, on the other hand, believed that they should program and prove for all the machines. They argued that CNC is designed to be worked by cheap, semi-skilled, labour. This view was also shared by the new senior management team, who were considering further investment in CNC. They wished to see CNC re-organised so that the programmers did all the programming, the existing operators became setters who also proved out the tapes, and the machines would be operated by unskilled or semi-skilled workers.

Wilkinson argues from this that technical change in this case and others is a political process in which various individuals and groups seek to maintain or increase their power. They achieve this by influencing technical change so that it favours them rather than others in the organisation. This leads to clashes of interest not only between managers and workers, but also within management and within the workforce. He sees technical change extending over a long period of time, and at each stage in the change process, a battle taking place over the outcome.

Shaiken (1979 and 1980)

These two papers by Shaiken are an attempt to present the American experience of CNC. They are based largely on secondary sources, though some interviews with managers and operators also appear to have been carried out. Shaiken examines the rationale for CNC, its current effect, and its future consequences. His main interest is in the effect of economic systems upon technical change, but he also examines the importance of batch size and product complexity. However, issues such as organisational culture, individual values and divisions within management and workers are not examined.

The findings:

Shaiken argues that:-

i) CNC is part of a management system that centralises authority over workers and leads to their deskilling;

ii) CNC weakens the individual and collective power of workers;

iii) Management are aware of this and consciously introduce CNC in such a way that it will deskill workers and reduce their bargaining power;

iv) This tendency is inevitable in a capitalist, profit-orientated, society.

Nevertheless, Shaiken does show that CNC can, in some cases, be used to maintain and increase workers' skill and power, especially where small batches of complex components are concerned. This is because, he argues, efficient production requires the active participation of skilled workers. He points out from this that there is nothing inherent in CNC that leads to its being used to deskill workers. However, he argues that, under a capitalist system, technology will tend to be used to control and deskill workers rather than the reverse, and that this can only be overcome by a fundamental change of the economic system.

CONCLUSION

In the first section of this chapter, it was argued that CNC was not a deterministic technology - there are choices as to how work is organised around it. This view has been borne out by the five case studies, which have shown that CNC use varies from organisation to organisation. Despite the fact that these studies, with the exception of Sorge et al (1983), were based on limited empirical evidence, they did draw attention to a number of factors which are important in influencing how CNC is used.

Sorge et al (1983) pointed to the importance of plant and batch size, but in addition also showed the importance of different countries' socio-technical traditions. Black (1983) drew attention to management objectives, especially cost-cutting and control. Clegg et al (1984) argued that organisational values and structure were influential. Wilkinson (1983) pointed to the political nature of the change process. Shaiken (1979 and 1980) drew attention to the influence of the prevailing economic system.

On the surface, the fact that five studies reach differing conclusions on what influences CNC usage is confusing.

However, if these studies and their findings are seen in the light of the conceptual framework presented in Chapter 4, this confusion can be resolved. Rather than considering the findings from these studies as conflicting and confusing, they can be seen as partial explanations. Sorge et al are right to point to societal differences and plant and batch size; Black is right to point to management objectives; Clegg et al are right to point to organisational values; Wilkinson is right to point to the political nature of the change process; and Shaiken is right to draw attention to the nature of the economic system. However, the drawback of these studies is that they limit their explanations to a few factors rather than taking account of the multiplicity of pressures and restraints that organisations face when adopting new technology. The conceptual framework presented in Chapter 4 attempts to do this; it is argued that the change process is influenced by a wide range of factors, both external and internal to the organisation. Some of these factors will be more important than others, but these will vary from organisation to organisation and will also change over time. The nine case studies presented in the next four chapters will illustrate this, and show the need for a conceptual framework that draws attention to the wide range of organisational and societal factors that influence technical change.

PART TWO

PART TWO

INTRODUCTION

The next four chapters will present nine case studies of the introduction and impact of CNC. Chapters 7 and 8 will deal with its introduction into small companies; and Chapters 9 and 10 will deal with its introduction into medium-sized and large companies respectively.

Each case study will be presented, as far as possible, in a standard format - describing the company, the reasons for introducing CNC, its impact, and placing particular emphasis on the decision-making process and the factors which affected this - so as to allow comparisons to be made.

In order to aid this process, Tables 1 and 2 show, respectively, the number of sets of visits made to each company and when these took place; and the main people in each company who were interviewed. It should be noted with regard to Table 1 that the duration of a set of visits is not necessarily an indication of the number of people interviewed. This is because in some companies, it was possible to interview 3 or 4 people in one day, whilst in others, due to availability, this took 2 to 3 weeks. With regard to Table 2, this only covers the main people interviewed and not the numerous other people in each company, such as receptionists, secretaries, labourers, managers, with whom more informal conversations took place. Nor does it cover interviews with those outside of the company who were involved with CNC introduction. This is partly because the latter did not necessarily take place at the same time as company visits, and partly because, in a number of cases, the people in question had been involved with more than one of the companies.

Tables 1 and 2 should, hopefully, give an overview of when visits to each company took place and who was interviewed.

However, in the next four chapters, the companies will be presented as individual cases, with particular aspects highlighted, and comparisons between them will be made in Chapter 11 after all the studies have been presented.

TABLE 1: COMPANY VISITS

Case \ Date	1982	1983	1984	1985
(set of visits) CASE 1		(1) Sept/Nov	(2) July/Aug	
(set of visits) CASE 2			(1) Jan/Feb (2) Aug/Oct	
(set of visits) CASE 3	(1) Dec/Jan	(2) April/May (3) Nov/Dec	(4) April	
(set of visits) CASE 4		(1) Oct/Dec	(2) July	
(set of visits) CASE 5			(1) April/May	(2) Jan
(set of visits) CASE 6			(1) July/Aug	
(set of visits) CASE 7			(1) July (2) Nov	(3) Feb
(set of visits) CASE 8		(1) Jan/March	(2) Jan/Feb (3) Sept/Oct	
(set of visits) CASE 9		(1) Jan (2) March (3) Aug	(4) Feb (5) Dec/Feb	

TABLE 2: INTERVIEWEES IN EACH COMPANY

	CASE 1	CASE 2	CASE 3	CASE 4	CASE 5	CASE 6	CASE 7	CASE 8	CASE 9
FIRST SET OF VISITS	Technical Director Foreman Programmer Setter-operators (3) Operator Inspectors(2)	Works Director Works Manager Programmer Setter-operators (2) Inspectors(2) Conventional setter Shop steward	Managing Director Supervisor Setter-operators (9)	Managing Director Plant Manager Machine Shop Manager Programmer CNC Setters(2) CNC Operator/Minders (2) Conventional Setter/Shop Steward Inspector Electrician	Works Manager Machine Shop Superintendent Foreman Engineering Manager Programmer Setter-operators (6) Plant Manager	Engineering Manager Programmer Setter-operators (2) Supervisor	Engineering Manager Production Engineer	Industrial Engineering Manager Factory Manager Engineering Manager Production Engineers (3) Foreman Supervisors(2) Programmer-setter Setter-operator Operator Shop stewards (2)	Engineering Manager Engineers (2) Supervisor Shop Stewards' Committee
SECOND SET OF VISITS	Technical Director Works Director Foreman Programmer Setter-operators (3) Trainee setter-operator Maintenance fitter	Manufacturing Manager Works Manager Programmer Setter-operators (2)	Managing Director Setter-operators (6) Ex-Shop Steward	Plant Manager Machine Shop Manager Programmer CNC Setter CNC Operator/minder Shop Steward Electrician	Production Control Manager Foremen (2) Chargehand Engineering Manager Programmer Setters (4) Operators (3)		Engineering Manager Production engineer/programmer Setter-operators (2) Supervisor Work Study Engineer	Engineering Manager Production Engineers (4) Foreman Supervisors(3) Programmer-setter Setter-operator Operator	Engineering Manager Engineers (3) Production Manager Supervisor Setter-operators Shop Stewards' Committee
THIRD SET OF VISITS			Managing Director Setter-operators (4) Ex-setter-operators (2) Ex-Shop Steward Supervisor				Engineering Manager Production engineer/programmer Setter-operators	Engineering Manager Production Engineers (4) Foreman Supervisors(3) Programmer-setter Setter-operator Operator	Engineering Manager Engineers (2) Foreman Supervisor Setter-operators (2)
FOURTH SET OF VISITS			Managing Director Programmer Setter-operators (4)						Engineering Manager Engineers (2) Production Manager Supervisor Setter-operators (3)
FIFTH SET OF VISITS									Engineering Manager Production Manager Engineers (2) Supervisor Setter-operators (4)

CHAPTER SEVEN

SMALL COMPANIES PRODUCING SMALL BATCHES

CASE STUDY ONE

The Company

The company is a small, family-owned business established in 1891. It mainly manufactures high-quality components for the aerospace and nuclear power industries, though in the last few years it had become involved in more general sub-contract machining work.

The company was controlled by two members of the owning family, who were joint Managing Directors; however, the day-to-day running of the company was in the hands of the Technical Director and the Works Director, who were not family members. The company had been profitable up to 1981, but since then had "struggled to break even". This had led to a significant fall in the numbers employed: in 1979 approximately 100 people were employed at the company, but by 1983 this had fallen to below 50, due to the collapse of their main markets.

At the time of the first set of visits, 25 people were directly involved in production and the rest were either members of staff or ancillary shopfloor workers such as maintenance fitters or labourers. The two main production departments were fabrication, employing 12 people, and machining, also employing 12 people. The machine shop was established in 1970 as a support function to the fabrication department which, until recently, was seen as the main profit generator for the company. However, with the shortage of work, the machine shop had become more important in terms of company profitability than the fabrication department. This was because the machine shop had lost less work than the fabrication department, and it had also been more successful in diversifying into new markets. The company had bought four CNC machines in the last 10 years. The first was a lathe bought for £60,000 in 1975. The second was also a lathe, bought for £40,000 in 1980, and in the same year the company bought a machining centre for £70,000. The last was a second-hand CNC lathe purchased for £12,000 in 1984.

The machines were used, in the main, to produce complex components in small batches ranging from 10 to 50, though occasionally larger batches of simpler components were also manufactured. On the lathes, the machining times ranged from a few minutes to over an hour, though the average was around 30 minutes. On the machining centre, the cycle times were longer and could range from an hour to half a day, though the average was around 1½ hours. The set-up times for the lathes ranged from 2 to 3 hours if the job had been done before, to an entire day if a new tape needed proving. On the machining centre, the respective times ranged from half a day to 2 to 3 days. The time taken to write programs was longer on the machining centre, taking one to two days as averse to 3 to 4 hours for the lathes. In total, the company had over 200 different programs for the CNCs, of which one third were for the machining centre.

The visits to the company commenced in September 1983 and the last visit was made in August 1984. Initial contact was made with the Technical Director.

Relations between management and workers and within the company in general were relatively friendly and informal; although the constant trickle of redundancies obviously caused tension, overall the atmosphere was one of informal friendliness and co-operation.

As the Works Director put it:

> This is not a company where you can have rigidly-defined areas of responsibility. It's too small and too diverse for that, so you've just got to muck in where it's needed.

The company was unionised, though not all workers were in a union, but the unions only seemed active on the issue of pay, and in the last few years they appeared to have accepted low wage rises because of the company's lack of work. For the same reasons, they had not opposed redundancies.

The organisation of work prior to CNC

Prior to the introduction of CNC, the machine shop was equipped with some 30 or so conventional machines, and 5 or 6 automatic machines. The former were used for small batches of complex components and the latter for longer batches of simpler components. The conventional machines were operated by skilled machinists and the automatic machines, which were set up by a skilled setter, were operated by semi- or unskilled labour. The machine shop was controlled by a foreman who was directly responsible to the Works Director. The Technical Director's input was through the foreman and involved advice on machining methods and jig and fixture design. All machinists were on an output bonus system, but this was not extended to the setter-operators on CNC. However, then as now, the emphasis was on quality rather than quantity.

The reasons for introducing CNC

At the time of the first set of visits, the company had 3 CNCs. The first of these, a lathe, was bought in 1975. There were three reasons why the machine was bought:-

i) The Technical Director, who was responsible for the purchase of new equipment, had worked with NC at his previous company and believed that "CNC is the future for us".

ii) He believed that CNC would solve the problem of the shortage and high cost of skilled labour. In 1975, 4 skilled turners were retiring from the company and he anticipated that one CNC machine would replace them all.

iii) The final reason was that there was a prospect of a large contract which could be machined on the CNC and which would pay for the cost of the machine.

Therefore, the machine was bought, though the large contract failed to materialise.

The second and third CNCs were both bought in 1980. CNC 2, a small lathe, was bought because, as the Technical Director stated:

> . . . we made a very good profit in 1980 and we didn't want to pay tax on it. Therefore, we bought the CNC; we didn't need it there and then, but we thought it would fill a gap in our machining capacity.

CNC 3, a machining centre, was bought to overcome difficulties that were being experienced in machining some very complex components. In 1979, the company had bought a large, conventional milling machine in order to expand their capacity and thereby gain more orders. However, the machine could not cope with all the new products, and in order to manufacture, and retain, the new work, they purchased the machining centre.

The organisation of work around CNC

With regard to CNC 1, it had been the intention of the Technical Director, who was responsible for bringing it into production, that a setter-operator who would prove, and possibly even programme, would be employed. However, for the first four years that they had the machine, they could not find such a person. Therefore, the Technical Director took on the responsibility for writing and proving the programs and sometimes also for setting up the machine. The machine was operated by a succession of 5 or 6 machinists who were either fired or left. Then in 1979, a machinist was hired who eventually took over responsibility for both programming and operating the machine.

With regard to CNCs 2 and 3, the machinist on CNC 1 eventually became the programmer for these machines as well, and a separate setter-operator was employed to work CNC 3, whilst CNC 2 was operated either by the programmer or by an unskilled female operator who was employed on other duties as well. Consequently, the setter-operator from CNC 1 became an almost full-time programmer and a new setter-operator was put on CNC 1.

The problems with CNC

The main problem with CNC 1 appears to have been training and retaining operators. Between 1975 and 1979, some 5 or 6 operators worked the machine and all were either fired or left, apart from one apprentice who was tried for 6 weeks and then sent back to work conventional machines. The main reason for this situation appears to have been the expectations and attitudes of the

Technical Director rather than the quality of operator. He believed, and to an extent still did at the time of the study, that once a program was written, everything else - proving, setting up, operating - was straightforward. He also believed that learning how to operate the CNC was relatively easy. The following comments by the programmer and the foreman respectively illustrate these points:-

> I came as an operator. [The Technical Director] spent some time with me but I really had to learn myself . . . I didn't get any training really. He's not a good teacher. He thinks some things are so obvious that he shouldn't even have to tell you them.

> One of the main difficulties was that [the Technical Director] was acting as programmer and setter and he's not the best of teachers. He expects operators to pick things up the first time rather than taking it slowly, step by step. He always wants to get onto the next job - he'll do things very fast, tell the bloke everything is fine and then go away. The blokes on the machine just didn't know what was happening. If a problem arose on the CNC, [the Technical Director] would say, 'It was okay when I left it, what's the operator done wrong?'

A related reason for the problems was that the CNC and the Technical Director were on separate sites, some 5 - 10 minutes from each other (although this changed in 1982 when the machines were moved to the same site as the Technical Director). Therefore, if a problem occurred, the Technical Director had to be telephoned and usually had to go to the other site. Given that this was not always easy or convenient, long delays could occur which were frustrating for all concerned.

Eventually, in 1979, an operator with previous NC, though not CNC, experience was hired. He virtually taught himself to operate the machine, set it up, and prove tapes. Within a short space of time, he began to programme the machine as well.

A further problem was that the machine shop foreman never became involved with the CNC. This was because (a) there was no-one to teach him about the machine, and (b) he saw it as a problem area and wished to avoid it.

When the second CNC was bought, the operator-programmer on CNC 1 was sent on a setting course for it, and the Technical Director went on a programming course. However, the operator-programmer for CNC 1 became responsible for programming and setting CNC 2, and the Technical Director had little direct involvement in it. This was for two reasons:-

i) The Technical Director found programming time-consuming and irksome, and was only too glad to hand it over to someone else.

ii) A strong bond of friendship had grown up between him and the programmer, and he trusted him to be able to programme CNC 2 as well as he programmed CNC 1.

The only problem that had arisen with CNC 2 was that it was under-utilised; it could work for a few days and then stand idle for a few weeks. This was why there was no permanent operator for it. It tended to be used for medium batches, 100 - 200, of simple components and could be operated by a semi/unskilled machinist. For small batches, the operator-programmer from CNC 1 operated it.

When CNC 3 was purchased, the Technical Director once again went on a programming course and then, once again, handed over the programming of it to the existing programmer. A separate setter-operator was employed because the machine was in use full-time producing complex components. As far as CNC 3 was concerned, there appeared to be two main problems. The first was that the machine was highly unreliable; it often suffered either mechanical or electrical failure. The second problem was that the setter-operator on the machine was also considered unreliable, and in part was blamed for the problems of the machine. However, for three reasons, this seemed somewhat unfair:-

i) His training was inadequate. He received 2 weeks' training from the Technical Director, who, though he had been on a course for the machine, was perhaps not the best person to carry out training. The rest of his training was carried out by the programmer, who himself had received no training. Therefore, overall, the setter-operator's training for the machine left a lot to be desired.

ii) CNC 3 was a far more complex machine to operate than any of the other CNCs, and this obviously contributed to the problems that arose.

iii) It is difficult sometimes to distinguish between an operator error and an electronic fault. On these occasions, it appeared that there was a tendency to blame the operator rather than giving him the benefit of the doubt.

Nevertheless, the machine had become crucial to the company in that it was the only one capable of machining some of the complex products they made, and, therefore, any breakdown of the machine could be costly.

The situation at the first set of visits

The first visits began in September 1983, and at that time, the company had 3 CNC machines. CNC 1 was operating full-time on a one-shift system, and the company was very pleased with its performance and that of the setter-operator. CNC 2, on the other hand, worked infrequently, though when it did, there were few complaints. However, CNC 3 and its setter-operator were still seen as a problem area.

There were also other problems. The first concerned the lines of authority and responsibility within the company. Before CNC, the machine shop was the responsibility of the foreman, who reported to the Works Director. Theoretically, this was still the case; however, in practice, because the foreman knew very little about CNC, the CNC machines formed a separate section where the programmer acted as an unofficial supervisor and was responsible to the Technical Director. Therefore, the lines of authority and responsibility for CNC were somewhat confused.

The second problem related to the division of functions between the programmer and the setter-operators. The Technical Director decided that the setter-operators should do no programming or proving of programs, and that these functions should be left to the person who had originally been employed as operator on CNC 1. This was because he did not believe that most machinists were capable of carrying out these functions, and because if they did, they might, like the programmer, have to be paid more money.

However, in practice, the split of functions could vary on a day-to-day basis depending upon the availability of the programmer.

This was not only because he could be occupied operating on CNC 2 or proving on another machine, but also because sometimes CNC 1 or CNC 3 could be operated on two shifts, and in that case he acted as the setter-operator on one shift.

This had brought about situations where the setter-operators had been left to prove out new programs and even, in the case of CNC 1, to write them. Nevertheless, this was an unacknowledged part of their job, and the programmer insisted that it was his responsibility to programme and prove on all occasions. He argued this for two reasons:-

i) The programmer was paid more and had a higher status because he was the sole programmer/prover, even though he was still classed as a shopfloor employee. He felt that if some of these functions were given to setter-operators, his "indispensability" would be reduced and so might his pay and status. He also enjoyed programming and proving. As he said himself:-

> . . . if they [setter-operators] programmed or even proved out, there would not be enough for me to do . . . doing difficult programming jobs is a challenge, it makes the job better - more interesting.

ii) By proving as well as programming, he was also able to learn the best method to use for each job. This was because, particularly with complex components, there is usually more than one method of machining components. When proving out a program, it is possible to learn what works and what does not work by experimenting with different methods.

The setter-operators used similar arguments in support of their demand to prove and occasionally programme. These were that it would make their jobs more interesting and also, as they were on the machines all the time, they knew the best methods to use. In addition, they pointed out that it was a waste of money for them to do nothing while the programmer was proving out a tape on their machine.

The situation at the second set of visits

The second set of visits began in June 1984. The main change was that another CNC had been bought. It was the same model of machine and of a similar age to CNC 1. It was bought, in the words of the Technical Director, because "it was too good a bargain to miss". It was being sold second-hand for £12,000, and whilst the company was not seeking another CNC lathe, it was felt that the price made it attractive and, in any case, it could be used to relieve the workload on CNC 1, though in the short run at least there was not enough work to keep it occupied full-time. It had been used for only one spell of three weeks, but the intention was that it would have its own setter-operator who, when not working CNC, would operate conventional machines.

However, on the occasion that the machine had been used so far, it had not been possible to give the setter-operator designate much training on the machine, and it appeared that training would once again be a problem.

The programmer was responsible for training and he was aware that it was a problem; as he put it himself:-

> The trouble is they [management] won't let me train him. They wouldn't give me the time, so he's not had a lot of training. He can operate okay, but as far as setting up is concerned, he's had no training.

The problem of not providing time for training appeared to reflect the uncertainty of the Technical Director and the Works Director as to how CNC would develop within the company. By the second visits, it was clear that they saw CNC as the key to the company's future, but they were not sure how it should be used. On the one hand, they had talked of creating a separate CNC section with a supervisor/programmer, one or more setters and operators, who would mainly load and unload for each machine. On the other hand, they had also talked of training people to work as both setter-operators on CNC and skilled machinists on conventional machines.

Their main problem appeared to be that the uncertainty caused by the continuing decline in their market, which had brought further redundancies since the first set of visits, made forward planning difficult. As the Works Director said:-

> There is no forward look at anything . . . because we are too busy dealing with other things - putting our fingers in the dyke and dealing with day-to-day problems as they come up.

This inability to plan ahead was reflected in other aspects of CNC. The Technical Director suggested to the Board of Directors that a second CNC machining centre be bought. This was vetoed by the Works Director, who argued that until the problems - now perceived to imply the setter-operator - of the first machining centre had been resolved, they should not buy another. Therefore, a new CNC was not bought but neither had there been an attempt to replace or re-train the setter-operator on the existing machining centre.

At the end of the second, and last, series of visits, the company were convinced that CNC was their future, but were not sure - after 9 years of CNC experience - how to obtain the best results from it.

Conclusion

A number of points arise from this case study. The first point is that after 9 years of CNC experience, the company was still not sure what form of CNC organisation it wanted. This was due to two factors: firstly, that the company's management tended to react to events and deal with them on a piecemeal basis rather than planning for the future; secondly, that the uncertainty of their future order book made planning very difficult in any case.

The second point to note is that CNC development had, by and large, been the province of one person: the Technical Director. He had been responsible for the machines that were purchased and how they had been used. Yet he appeared to have evaded any real criticism from his fellow directors for the many problems that had arisen. This appears to be a prime example of how a senior manager, because of his ability to control the flow of information to his colleagues, managed to shift the blame for problems to those with less influence than himself.

The third point is that the formal organisation of the machine shop and the actual organisation of it were quite different. The most glaring example of this was the role of the foreman. Formally, he controlled the entire machine shop and was responsible to the Works Director. Informally, the main element of the machine shop, the CNC section, was controlled by the programmer, who, whilst formally responsible to the foreman, was actually responsible to the Technical Director.

The last point to note is the performance of the CNCs in technical, financial and human terms.

In technical terms, only CNC 3 could be said to be deficient in that it was mechanically and electronically unreliable. Whether or not this could have been avoided is uncertain, though in none of the cases of CNC purchase were there any extensive investigations into the machines' performance and reliability. In the main, the machines were observed at exhibitions and bought after discussion with the machine suppliers.

In financial terms, there were doubts about the machines: CNC 1 in its first four years with the company had not been a very productive machine, though it had been since 1979; CNC 2 had only worked infrequently; CNC 3 was often broken down; and it was not envisaged that CNC 4 would, in the near future, work full-time. The question is not whether CNC was the appropriate technology for the company, as - given the company's products - it obviously was, but whether or not the company had received value for money. Whilst this cannot be answered definitively without a financial examination of the company's accounts, it is possible to say that the financial returns could and should have been better.

In human terms, in terms of the quality of jobs that had been provided, the results were mixed. The programmer, on his own admission, had a very challenging and interesting job. The setter-operator on CNC 1 could also claim to have an interesting and varied job, but believed that this would be enhanced if he carried out more proving and programming, though this would in turn affect the programmer's job. The woman who occasionally operated CNC 2 found the job of loading and unloading the CNC boring, but because she only did it for short periods, she did not appear to mind this. The setter-operator on CNC 3 should have had a very interesting job, because of the complexity of the machine. However, the fact that the machine was unreliable and that he was often blamed for this made his job frustrating and unsatisfying. The quality of the operator's job on CNC 4 would depend on whether that person was trained to set the machine and sort out problems, or was merely expected to load and unload it.

In terms of the foreman's job, the advent of CNC had obviously affected it for the worse, in that it had resulted in his status and authority being undermined. It had also led to some redundancies, because work had been switched from conventional machines to the CNCs. Despite all this, the attitude of people in the company towards CNC was very positive; the main reason for this appeared to be that they considered CNC to be "the future", and that if they did not adopt it as a company, they would go out of business.

CASE STUDY TWO

The Company

The company was established in 1705 and is involved in making cutting tools for the mining industry - 80% of its production is bought by the National Coal Board. Up to 1981, it was a family-owned company, but then it, and a subsidiary making a complementary range of products, were sold to an investment trust based in the South of England.

Before the sale, the company had been profitable, and this continued up to 1983, when there was a sharp decline in their market. This resulted in the workforce being reduced from 80 to 60, which was the number employed when the first set of visits began. The 60 were split evenly between office and shopfloor. The main shopfloor departments were welding, where 8 people were employed, and the machine shop, which employed 12. The other shopfloor workers performed various ancillary tasks.

The company was controlled by 3 directors, who were also the directors of the subsidiary. The day-to-day control of production was in the hands of the Works Director, who had been with the company for 10 years. Beneath him was a Works Manager, who was assisted in the machine shop by a supervisor who was also responsible for setting up a number of automatic machines.

The company had one CNC lathe which it purchased for £20,000 in March 1983. It also had two NC drilling machines which had been bought second-hand in 1980. The CNC was bought, and originally used, to produce a small range of components which were produced in batches of 25 and 50. Production time for each component was $1\frac{1}{2}$ hours, but this was because they were large rather than particularly complex. The programming time for these jobs was 3 to 4 hours, and proving and setting up the machine took 1 to 2 hours. However, in 1984, the machine also began to be used to produce longer runs of simpler components. The total number of programs produced for the machine was 12.

The first visit to the company was in January 1984 and the last was in September 1984. Initial contact was made with the Works Director. Management-worker relations within the company were friendly, though they appeared to have been soured somewhat by the redundancies. Most shopfloor workers were in a trade union, but the union was not active either over pay or redundancies.

The organisation of work prior to CNC

Before the CNC was introduced, there were some 20 people employed in the machine shop. These were split into those who operated automatic or semi-automatic machines, and those who worked conventional machines. The latter were more skilled than the former, but the company's management considered their workforce, in general, to be low-skilled. This appeared to be due to the simple nature of the products made and the fact that operators tended to be allocated to the same machines and the same narrow range of products all the time.

The company operated a piecework bonus system which was extended to the CNC machine when it was installed. Supervision was provided partly by the setter on the automatic machines, but mainly by the Works Manager. The Works Director also spent a significant amount of time on the shopfloor, and the general impression was one of close supervision.

The two NC drilling machines were infrequently used, and when they were, the Works Manager would operate them.

The reasons for introducing CNC

The main person responsible for the purchase of the CNC machine was the Works Director. He was responsible for all equipment purchases, but, according to his colleagues, he tended to buy cheap, second-hand machines which, in most cases, proved not to be good buys.

His reasons for buying CNC were that:-

i) He believed that CNC was the future technology for the industry and that the company would be left behind if they did not, as he put it, "jump on the CNC bandwagon".

ii) Their main customer, the National Coal Board, had tightened up its quality control procedures and he believed that the company's existing machines and machinists were not good enough to produce the quality required consistently.

iii) He was offered a CNC lathe at £20,000, some 50% of its normal price. This was because it was an exhibition model. It was this offer of a "cheap" machine that finally made the company buy a CNC though in fact they had been looking for one for some time.

The organisation of work around CNC

The programming of the CNC was done by a work study engineer who was also responsible for programming the NC machines. However, his main job was work study, and programming was not seen as constituting the major part of his work. The machine was worked on a one-shift system by two setter-operators who, in theory, alternated between operating the CNC lathe and the NC drilling machines. As well as setting and operating the machine, they also, in conjunction with the programmer, proved out new programs.

The problems with CNC

The main problem was getting the CNC into full production. This was for three reasons:-

i) The machine was delivered in March 1983 but it was not until three months later that the supplier's staff arrived to install the machine and give training. (Given the importance the company attached to CNC, this delay seems strange).

ii) Lack of training for the programmer: the company, in anticipation of buying a CNC, had hired a CNC setter-operator in January 1983. He was hired to work the NC machines and told he would be put on CNC when one was bought. However, when the machine arrived in March, the company hired another setter-operator. These two employees were supposed to alternate between the CNC and the NCs, but in practice the second CNC setter-operator spent most time on the machine. This appeared to be because his colleague's work had not impressed the Works Director or the Works Manager.

Therefore, the company had ensured that the skills were available to set up and operate the machine. However, it was less successful in ensuring that the programming skills were available. The work study engineer received two days' training in programming from the supplier's training staff and, not surprisingly, he found this inadequate:-

> The [supplier's] engineer just stood at a blackboard and taught me. It was all new to me, I didn't realise what was happening. It took 8 months before it started to slip into place.

His experience in programming the NC machines proved of little help because, as he said:-

> You can't compare the NCs to the CNC. The NC drillers are child's play compared with the CNC.

Therefore, the production of programs proved problematic and slowed down the introduction process. In fact, for some months, he had to rely on the programming knowledge of the setter-operators, which they had gained prior to coming to the company. As one of them commented:-

> When we [the two setter-operators] first started with the CNC, the programmer was completely fresh to all this type of work. So we had to more or less show him how to programme - he admitted we knew more than he did. He made mistakes like I did when I first started to programme and we spent a lot of time putting them right . . .

The main reason for the lack of training for the programmer was that the Works Director assumed that programming would not be a problem. He thought that writing tapes for CNC was the same as for the NC drilling machines. Indeed, as he admitted himself, he was somewhat naive about CNC and had believed that tapes were simple to produce and could be put straight into the CNC, and that it would start producing straight away.

iii) There was a lack of work for the CNC. It was bought under the assumption that it would produce a range of 3 or 4 components, all basically the same, and that CNC would allow the company to attract new orders which would keep it occupied for the rest of the time. However, when they bought the machine, their market went into decline, and there was less "old" work and certainly no new work.

They could have switched more work from the conventional machines, but it was felt that this might have caused problems. As the Works Manager said:-

> CNC was new to us and we've had a bit of a struggle adapting to it, and with work being short as well, that's made it a bit more awkward because [the conventional operators] have wanted work on their machines rather than CNC, so we've had to keep them happy and that's meant work's been short on the CNC.

Therefore, for a variety of reasons, the process of introducing the CNC was slow and, either because of lack of work or problems with the programs, the machine was idle as often as it was working.

The situation at the first set of visits

When the first set of visits began in January 1984, the management of the company felt that the early problems that had slowed down the introduction of CNC had been overcome - apart, that is, from lack of work. The programmer, for his part, felt that the lack of work had allowed him the time he needed to learn CNC and was relatively confident with it. However, four problems connected with the setter-operators were beginning to emerge:-

i) The first setter-operator was becoming increasingly frustrated that he spent so little time on the CNC, and that even when he was on it, he tended only to load and unload it because it had already been set up by the other setter-operator.

ii) The second setter-operator was also unhappy. When he first started at the company, he found himself closely involved in programming and proving. However, as time went on and the programmer became more proficient and new programs became fewer, he spent more time simply operating the CNC. He had enjoyed being involved in programming, but found operating boring.

iii) They were both unhappy about their pay. When they were working the CNC, they were paid according to the same bonus system as everyone else. However, the CNC program rather than the operator controls the rate of production. Under the standard bonus system, this would have prevented them from earning any bonus. To overcome this, their production targets were "fixed" to allow them to earn £15 per week bonus. To an extent, this was acceptable whilst the machine was working, but if, as often happened, it was not, then the operators lost their bonus. In addition, on the conventional machines, some operators, though by no means all, could earn £30 bonus. This upset the setter-operators, who felt that they should be paid no less than the highest-paid conventional operator.

iv) The quality of work from the CNC was decreasing. One of the main selling points for CNC is its repeatability: its consistent quality; yet the machine was producing components that did vary. This appeared to be the fault of the second setter-operator, who was not inspecting his work properly.

Therefore, at the time of the first set of visits, there were still problems with the organisation of work around CNC.

<u>The situation at the second set of visits</u>

When the second set of visits began in August 1984, the company's financial position had drastically deteriorated owing to the dispute within the coal mining industry, which had then been running for six months. As an example, the company should have had a monthly output of £80,000; in July 1984, it had been £14,000 - and half of that had been cancelled. The situation was the same for the company's subsidiary. The company's owners decided to take drastic action; they proposed to amalgamate the company and its subsidiary on one site. They had also made half the workforce from the combined companies redundant, including the Works Director.

However, other than the Works Director, all the staff who had previously been associated with CNC were retained. Nevertheless, the changes did have an impact upon CNC, the main change being that the majority of turning work was being done on CNC. This was because all except one of the conventional turners had been made redundant. The CNC was therefore producing a different type of work: simple components in batches of 250 to 500.

This change appeared to have eliminated one problem, but to have exacerbated others. The problem of the need to keep the conventional operators "happy" by keeping work on their machines had been eliminated, as there was now only one such operator. The problems which had been exacerbated were related to the nature of the setter-operators' jobs and the quality of work.

When the first visits were made, there was already evidence that the setter-operators had become dissatisfied with their job. This had now intensified, for four reasons:-

i) They were now producing larger batches of simpler components, with shorter cycle times, which they found boring, monotonous and physically more demanding.

ii) All the programs for the jobs they were doing had been proved - they had not required a new program for some 3 - 4 months - and therefore the satisfaction to be gained from helping with programming was gone. In addition, the simpler jobs proved less of a problem to programme in any case and the programmer did not need to call upon the advice of the setter-operators.

iii) They were still dissatisfied with their pay.

iv) The general uncertainty regarding the company's future also added to their general feeling of dissatisfaction.

This dissatisfaction had two consequences. Firstly, the first CNC setter-operator was actively seeking another job. The second setter-operator was not looking for another job, mainly because the new site that the company was moving to was appreciably nearer his home and therefore suited his travel arrangements better.

The second consequence of their dissatisfaction was that the quality of work from the CNC continued to decline. The setter-opperators, mainly the second one who worked the machine most often, were not checking their work properly, or even in some cases checking it at all. They said they were not paid to check their work, and that in any case, the machine should produce the work accurately without the need for frequent checks.

There was one final problem which had arisen since the first visit: the CNC machine had broken down, and had had to be repaired at a cost of £1,000. The breakdown was caused by the fact that the original components that the machine was bought to manufacture, and still manufactured, were too heavy for the machine. This was a problem which, apparently, would re-occur as long as the machine was used to manufacture this type of work.

Conclusion

A number of points arise from this case study. The first is that the decisions to buy CNC and how to use it were, by and large, taken by one person: the Works Director. He was given a free hand by his fellow directors with regard to machine purchase and the organisation of work around CNC.

The second point to note is the difference between the formal and actual organisation of work, especially the role of the programmer. In theory, the setter-operators were responsible to the Works Manager, who had received some CNC training, but in practice they were responsible to the programmer. Nevertheless, this had not always been the case. Originally, the setter-operators, because of their greater knowledge of programming, had more influence over the programmer's work than he had over theirs. However, as the programmer became more experienced, he took on more of the responsibility for programming and proving, and the setter-operators became less involved in this aspect of CNC. This resulted in the programmer taking the main responsibility for CNC.

The final point relates to the performance of the machine in technical, financial and human terms.

In technical terms, it may be that the wrong machine was bought. Certainly, the type of components the machine was originally bought to produce appeared unsuited to it in that they were too heavy.

Financially, the machine, when there was work for it, appeared to be justified by the speed with which it produced work, but if it continued to break down and to be expensive to repair, then repair costs would swallow up the financial benefits.

In terms of the quality of jobs that were produced, the results were mixed. The programmer, now that he had gained experience and confidence, enjoyed programming, but he was only called upon infrequently to do so, and his occupation was still work study. The setter-operators did not enjoy their jobs and were dissatisfied. The first setter-operator, who spent most time working the NC drilling machines, found his job monotonous and boring. The second setter-operator had found that his reduced involvement in programming and proving, coupled with the lack of variety in the work he did, had also made his job boring and tedious. There was evidence in both cases that this had affected their performance in terms of the quality of their work.

In terms of the Works Manager's job, CNC appeared to have made few differences. Some of the problems that he would deal with on conventional machines were dealt with by the programmer, but, especially since the departure of the Works Director, the Works Manager had a very heavy workload and was happy to see some of his normal duties done by others in any case.

As a final comment, it must be pointed out that, in this company, CNC introduction and use had been overshadowed by the company's financial situation. If the company had had a full order book, then the programmer would have had less time to devote to programming, which would have necessitated greater involvement by the setter-operators; however, that was not the case.

CHAPTER EIGHT

SMALL COMPANIES PRODUCING LARGE BATCHES

CASE STUDY THREE

The Company

This is a small privately-owned company established in 1967 by the present owner, who is also the Managing Director. The company is exclusively involved in high-quality sub-contract machining activities for a wide variety of customers and industries.

Employment at the company fluctuated between 20 and 30 people, all but four of whom were supervisory or shopfloor employees. The owner was the sole working director, and he took responsibility for the day-to-day control of production. He was assisted in the office by a production engineer/programmer, and on the shopfloor by two supervisors, one of whom was responsible for CNC machines and the other for conventional machines. The rest of the workforce, excluding two or three ancillary workers, were employed as machinists and operated either conventional or CNC machines. At the time of the first visit, there were 14 CNC machinists and approximately 5 conventional ones. The former operated 9 CNC machines, some on two shifts, which were bought for some £600,000 between 1978 and 1982.

The company was profitable and, according to the Managing Director, had weathered the recession better than their competitors; he attributed this to the acquisition of CNC.

Seven of the CNC machines were lathes and two were machining centres. They were used to produce a wide variety of high-quality components in batches ranging from 50 to 2000, though the norm was around 300. Machining times on the lathes varied between two and ten minutes, and on the machining centres from 30 minutes to two hours. The set-up times for the lathes ranged from one to three hours and on the machining centres from one to three days. These times could be doubled or trebled when a new program had to be proved. The time to write programs for the lathes was two to three hours, and for the machining centres it was two to three days. The company had some 2,000 different programs, 90% of which were for the lathes, which were continually being added to.

The visits to the company commenced in December 1982 and finished in August 1984, and the initial contact was with the Managing Director. Management-worker relations, which in this instance meant the relationship between the Managing Director and everyone else, were highly hostile. The main reason for this appeared to be the Managing Director's authoritarian, not to say bullying, style of management. Consequently, there was a high labour turnover, due to people either leaving or being sacked. Indeed, of the 9 CNC machinists spoken to on the first set of visits, only one was still working at the company when the final visit took place, and many more - one person put the figure at 20 - had come and gone in this period. This led one CNC machinist to remark:

> I don't think of this place as a factory, more as a social centre - you're always meeting somebody new.

The company was not unionised when first visited, but attempts were later made by the workers to join a union. The result of this was that those actively involved in the union either were sacked, made "redundant", or found life so unpleasant that they left of their own volition.

The organisation of work prior to CNC

Before the introduction of CNC, the machine shop was equipped with a variety of conventional, automatic and semi-automatic machines. In the main, the level of skill was high; this reflected the need for workers who could cope with a high variety of complex work. The company did not operate a bonus system then, and still did not at the time of the study. There were two supervisors on the shopfloor and also a Works Manager, who was responsible for day-to-day production. At this time, the Managing Director spent very little of his time involved in the control of production. According to employees there at the time, the company was a reasonably friendly one to work for.

The reasons for introducing CNC

The Managing Director first began to consider buying CNC in 1976. This was for two reasons:-

i) The company's market was shrinking and competition was increasing; if the company was to survive, it needed to become more competitive by cutting its costs.

ii) He believed that CNC was not only more productive but would also allow greater control of labour and reduce the need for skilled workers, and thus reduce wage costs.

As the Managing Director put it:-

> My main emphasis in developing CNC is to try to become independent of the need for skilled shopfloor workers who have control over output and quality and who use this to bargain over wages.

These were the reasons why the company bought its first CNC in 1978, and then went on to buy another 8 between then and 1982.

The organisation of work around CNC

The Managing Director decided that his production engineer would be responsible for writing and proving out programs. Setter-operators were to be employed to load and unload the machines and to set them up, but they were not to have any involvement in proving or programming. A supervisor, with CNC experience, was appointed to look after the CNC section and to deal with problems.

However, the Managing Director assumed that programs would be right the first time, and that there would be few problems. He also assumed that, once the machines were set up, all the setter-operators would have to do would be to load and unload, and that the speed of the machine and, therefore, their pace of work would be controlled by the program. As will be described in the next section, this view was somewhat naive; many problems arose and the setter-operators became involved not only in proving tapes but also, in some cases, in actually writing programs.

The problems with CNC

There were two major problems:-

i) Management-worker relations rapidly worsened, and labour turnover increased. This appeared to be because the Managing Director sacked his Works Manager and took over his responsibilities for production. He felt that in order to get the best out of CNC, he needed to take personal control over its introduction and use. However, his constant presence on the shopfloor, as one machinist said:

> . . . puts excessive pressure on shopfloor workers. People are afraid of him. When he's down on the shopfloor they do literally become apprehensive and afraid . . . If he changed his attitude he'd get a lot more out of his men; he'd get them willing to work rather than working because they were afraid of him.

He was quite ready, as one person put it, "to sack you at the drop of a hat if your face doesn't fit". There was also, not surprisingly, a high incidence of workers leaving of their own accord.

ii) The organisation of work proved far more problematic than the Managing Director had anticipated. It had been his original intention, as mentioned earlier, that the company's production engineer would be responsible for writing and proving programs, and that each machine would have a setter-operator, who would be responsible for setting up the CNC and operating it, but not for any programming or proving functions. However, this did not come about, for the following reasons:-

a) The programmer (production engineer) had to deal with far more work than he could cope with and this led to programming errors. In any case, it is very unusual for tapes to be correct first time, and they nearly always need proving on the machine. Because of his workload, proving, which on complex tapes could be very time-consuming, tended to be left to the operators.

b) Part of the programmer's problem was the number and variety of machines: there were nine machines, which between them had five different types of control language. This reduced the programmer's chance of becoming proficient in any one language.

c) The programmer lacked a machinist's background, and because of this, had to seek advice from operators regarding the machining of more complex components. This lack of experience also led to simple, but costly, programming errors.

d) The working hours of the programmer did not coincide with those of the operators, who worked a combination of shifts, overtime and weekend working. Therefore, there was a considerable part of the working week when the operators were left to their own devices to sort out problems.

e) The pressure of work, and the Managing Director's general attitude, caused programmers to leave: at the time of the first visit, the company had its third in four years. This had prevented any one programmer remaining long enough to become fully conversant with programming.

The result of this was that a series of ad hoc arrangements grew up. Sometimes, the programmer would prove a tape, but mostly the setter-operators would do it; mostly the programmer would write tapes, but sometimes setter-operators would do it, and in the case of two setter-operators, this became a fairly regular occurrence; also, the Managing Director would, very occasionally, programme. This caused a greater need for the involvement of skilled setter-operators. However, the involvement of so many different people in programming resulted in a confused situation whereby, when jobs which had existing programs were made again, the programmer or setter-operator might re-write the program because they did not like the way it had been done previously. The Managing Director saw no need to standardise the programming procedure because, in his view, only the programmer should programme; if anyone else wrote programs, it should, he believed, be merely an isolated occurrence that should not be repeated. This confusion was compounded by the high labour turnover; each new person had their own approach.

This was the situation when visits to the company commenced.

The situation at the first set of visits

The first set of visits began in December 1982. The situation was very much as described in the previous section, and this left the Managing Director with two problems:-

i) He had just appointed a new programmer, his third in four years, but, whilst the person had previous programming experience, the Managing Director did not believe he had the ability to do the job.

ii) The new programmer would obviously take time to learn how to programme all the machines, and in the interim greater setter-operator involvement would be required. However, the high rate of labour turnover meant that many of these people had little CNC experience. They received minimal training at the company; if they had no previous CNC experience, they were shown how to load and unload the machine, and were expected to pick the rest up from other machinists.

The Managing Director responded to these problems in two ways:-

i) He decided to buy a computer, costing £10,000, to produce CNC programs, because:-

   a) he hoped that programs could be quickly written and proved out on the computer, thus eliminating the need for shopfloor programming and proving.

   b) the computer used just one language and then converted the program into the language of the particular CNC machine. It also did all the necessary calculations to produce a tape and, therefore, could be operated, the owner hoped, by a less skilled person than a production engineer.

   Therefore, he hoped the computer would, in the long term, reduce the need for shopfloor and office programming skills.

ii) To cope with his problems in the interim, he was trying to recruit workers with CNC experience, and was also examining the possibility of sending some of his own workers on a CNC training course. However, he was worried that if he upgraded their skills, they would then leave for better jobs elsewhere.

This was the situation at the end of the first set of visits.

<u>The situation at the second set of visits</u>

The next set of visits commenced in April 1983. There had been two developments since the previous visits.

The first was that four setter-operators were attending a four-week, full-time, CNC training course. This was for two reasons:-

i) Other attempts to attract skilled CNC workers had not proved particularly successful. In addition, 3 experienced setter-operators had left. Neither occurrence was surprising, given the Managing Director's attitude to his workforce: he openly told them that if he found someone better than them, he would fire them and hire the new person.

ii) The training course, including wages, was paid for by the Manpower Services Commission, and, therefore, there was no financial cost to the company.

The second development was that the computer to produce CNC programs had been installed. However this was not proving to be as useful as the Managing Director had hoped, for three reasons:-

i) There had been problems with the computer's software which had only recently been resolved.

ii) The computer was much more difficult to operate than he had anticipated and appeared to be no quicker than manual programming.

iii) It transpired that the computer was only compatible with four of the nine CNC machines, and therefore the tapes for the other five machines were having to be produced manually. However, the Managing Director attributed this to "teething trouble".

The programmer who had been appointed at the time of the first set of visits was still with the company, but the Managing Director was actively seeking to replace him and he, for his part, was intending to leave.

The situation with CNC at the third set of visits

The third set of visits began in November 1983. Since the previous visits, there had been a number of further developments within the company.

The first was that most of the workers had joined a trade union. Given the situation at the company, this hardly came as a surprise. The Managing Director's response was not surprising either; after some weeks of bitterness, he made the shop steward redundant. The workers then elected another shop steward who, within a few weeks, was sacked, as was another union activist. This time, the workforce threatened to go on strike unless their two colleagues were reinstated, but the sacked shop steward said that he and the other person wanted to leave. He commented:-

> We were glad to go and he [the Managing Director] was glad to get rid of us . . . I couldn't have stuck it much longer anyway; I was dreading going to work. . . it was his [the Managing Director's] attitude . . . he wants to really dominate his workers.

This had happened just before the third set of visits began, and it appeared to have ended the attempt to unionise the company. As one of the remaining workers remarked:-

> He [the Managing Director] never gave in; it's just been a systematic attempt to smash the union. He's achieved it.

The second development was that, of the four people sent for CNC training, two had been fired, one was working a conventional machine, and only one was actually working on a CNC machine. Therefore, the training had not really helped to meet the need for skilled setter-operators.

The third development was that the old programmer was no longer with the company and a new programmer had been appointed who had previous experience of using computers to make programs. However, this did not solve the programming/proving problems of the company because:-

i) It was now apparent that the computer was only capable of producing programs for four of the nine CNCs.

ii) Even for machines that the computer was compatible with, it was sometimes easier to produce the programs manually.

iii) The computer was not any faster, even in the hands of an experienced user, than the manual method. It was more accurate, but programs still needed to be proved out, because programming mistakes could still be made. It was also the case that such factors as the speeds, feeds and methods were still specified by the programmer, and were subject to error and needed to be checked.

Therefore, the computer was not the solution to the programming/proving problems that the Managing Director had hoped.

The fourth development was that the company was selling some of its CNC machines. One was in the process of being sold, and there were plans to sell two more. There were two reasons for this:-

i) The machines were old and maintenance costs were increasing.

ii) They were machines that were not compatible with the computer.

The latter seemed to be the main reason as far as the Managing Director was concerned:-

> I shall never ever get the benefits I expected from the [computer] until I'm equipped with machines that are totally suited to it. With hindsight, the addition of the [computer] is likely to complicate matters rather than simplify them . . . until we've got rid of the old machines which are not compatible to it.

<u>The situation at the fourth set of visits</u>

The last set of visits took place in August 1984. Since the previous visits, there had again been a number of notable developments.

The first was that management-worker relations had improved. The cause of this appeared to be that the Managing Director was spending far less time on the shopfloor and was leaving staff management to the programmer and the supervisors. A contributory factor was that wages had also been increased. It appeared that the Managing Director had found his problems with the trade union, which was no longer active, a chastening experience and, as the programmer put it:-

> He's finally realised that he needs a stable workforce and that high labour turnover was counter-productive. It'd reached the stage where blokes were using the company as a training ground for CNC and then getting jobs elsewhere.

The second development was that the company now had only five CNC machines, and no immediate plans to increase this number. There were two reasons for this:-

i) The Managing Director only wanted machines that were compatible with the programming computer.

ii) He believed that many of the labour and organisational problems that had arisen were caused by acquiring so many CNCs too quickly. He saw the reduction in the number of machines as a way of reducing these problems.

The third development was that the programmer was attempting to standardise the production of programs; he was highly critical of many of the existing programs, and was changing them when they were repeated. He was doing all the programming, and the setter-operators were proving out. He had also adopted the practice of consulting them regarding production methods. He was using the computer as an aid to tape preparation, but its main benefit appeared to be that it simplified some of the complex calculations involved in programming, rather than simplifying or speeding up the entire process.

Conclusion

A number of points arise from this case study. The first is that only after 6 years of CNC experience did the company appear to be moving to a stable organisation of work around CNC. The problems that arose, in the main, revolved around the personality of the Managing Director, whose manner and actions caused bad labour relations and a high turnover of labour, which was counter-productive in terms of the efficient working of the organisation.

The second point to note is the difference between the formal organisation of work and the actual organisation. Formally, the programmer wrote the programs and proved them; informally, many ad hoc arrangements involving setter-operators were utilised to perform these functions. Formally, the supervisors were responsible for shopfloor workers and for sorting out any problems that arose; in practice, the Managing Director often took direct responsibility for these tasks. The Managing Director was aware of the many problems that existed, but just as he originally turned to CNC as the answer to his labour control problems, he turned to a programming computer to solve them. However, it did appear by the final visits that he might have come to grips with the root cause of the company's problems - his managerial style - and it may well be that by reducing his role in staff management, by reducing the programmer's workload and by acknowledging the importance of setter-operators in proving tapes, the formal and informal organisations would be brought into line.

The last point to note is the performance of the CNCs in technical, financial and human terms.

Technically, the machines appeared to have been reasonably reliable; however, the fact that the nine machines had five different programming languages between them caused obvious problems for those involved in programming.

In financial terms, there could be no doubt that CNC was ideally suited to the wide variety of work that the company performed. However, the high labour turnover and other problems meant that the financial performance of the machines was less than it should have been.

In human terms, the CNCs offered both the programmer and setter-operators varied and challenging jobs, but the benefits from this were overshadowed by the poor labour relations in the company.

The same comment could apply to the supervisor's job; a variety of people occupied this post, but most had CNC experience and should have found their jobs interesting, given the type of product the company made; but because of the attitude of the Managing Director, they did not.

In summary, it appears that the introduction and use of CNC in this company was shaped, and marred, by the personality of the Managing Director.

CASE STUDY FOUR

The Company

This is a small family-owned company originally established in 1841. Its main products are a variety of manually-operated pumps, and ancillary equipment for dispensing oil and other liquids. Its main market was the oil industry, but this had been declining since the mid-1970s and this appeared to be the main reason why the numbers employed in the company had fallen from 260 in 1973 to 100 in 1983.

The day-to-day control of production lay with the Production Director, but financial control and the buying of new equipment was the responsibility of the Managing Director, who was a member of the owning family.

Despite the decline in their market, the company had continued to be profitable, though, according to the Managing Director, at a lower level than they would like. The majority of the workforce, some 70 to 80 people, were either shopfloor employees or supervisory staff. These were split between four main departments: the foundry, the press shop, the machine shop and the assembly department. The machine shop employed some 20 people at the time of the first visit, and was controlled by a manager who was also responsible for setting up a number of automatic machines.

The company had two CNC lathes, costing approximately £50,000 each. The first was bought at the beginning of 1982, and the second 12 months later. The machines produced a variety of simple components. The normal batch size was 1,000, but this could be as high as 3,000 or as low as 200 on occasions, though

500 was the smallest batch they would normally produce on the CNC. The cycle time per component was between $1\frac{1}{2}$ and $2\frac{1}{2}$ minutes, and the components were quite simple. The programming time per component was approximately 2 hours and the setting-up time for the machines was around 1 hour. Proving-out time for new tapes took about 1 hour, but could be longer. There were 130 programs for the CNCs, and this figure was unlikely to increase appreciably in the future.

The first visit to the company was in October 1983 and the last visit was in August 1984. The initial contact was made through the Managing Director.

Management-worker relations in the company were very good, and the atmosphere was very friendly indeed. There were complaints of low pay and of fear of redundancies, but none of the blame for these was directed against management.

The company was trade union-organised and the shop steward in the machine shop was very complimentary about the company's management. The union were consulted over pay, redundancies and the introduction of new equipment, but viewed the first two as out of the company's control, given the market situation, and the latter was seen as "progress" which had to be accepted.

The organisation of work prior to CNC

Both before and after the introduction of CNC, the machine shop operated as an almost independent unit. The manager received a weekly list of work to be produced and when it was required, and was then expected to work with little or no interference from senior managers.

There appeared to be three reasons for this:-

i) There was a high degree of friendliness and trust within the company, and it was expected that people would get on with the work in hand without constant supervision.

ii) Almost all those in the machine shop, including the manager, were on either an individual or collective bonus that was related to output. Therefore, it was in their financial interest to ensure that output targets were met.

iii) The company is located in a four-storey building with the machine shop on the top floor, and senior managers are located on the ground floor. This appeared to act as a disincentive for managers to visit the machine shop.

Before the CNC machines were purchased, work was produced on a variety of automatic and semi-automatic machines. There were 5 setters, including the machine shop manager, and some 15 - 20 operators. The setters were classed as skilled but the operators, mainly women, were classed as semi-skilled. Operators tended to be restricted to working one or two machines, on which they carried out one or two operations on a small range of simple components. There was also a quality inspector and one or two ancillary staff.

Supervision in the shop was the responsibility of the manager and his assistant, also a setter, but in practice the other setters and the inspector also, as one of the setters said, "keep an eye on things".

The reasons for introducing CNC

The company had a general policy of modernising its plant and equipment on a regular basis. As the Managing Director put it:-

> We pride ourselves on being well up in equipment innovation. We really have put new equipment in at a very early stage . . . We saw CNC as the next generation of equipment.

Apart from this, there were three specific reasons for introducing CNC.

i) The company wished to introduce cheaper production methods in the machine shop. Their existing machines had been bought to produce components in batches of 10,000, but since then their average batch size had fallen to 1,000, and sometimes a lot less. Therefore, they were looking for a machine that could produce smaller batches at a more economical rate; they believed that CNC would do this.

ii) They believed that CNC would increase quality, though this had not really been a problem in the past.

iii) The Managing Director believed that there would be a labour shortage if the market revived; he saw CNC as a way of eliminating this problem due to its greater productivity.

These were also the reasons why, 12 months after buying the first CNC, they bought a second one.

The organisation of work around CNC

The programming and proving out of tapes for the CNC was done by a draughtsman, whose main responsibility was to programme the

CNC but who also carried out some draughting functions. The non-programming setting of the machine was done by any one of three setters, one of whom was the machine shop manager. One of the CNCs had an operator whose job was to load and unload the CNC and to "mind" it whilst it was running. However, if anything should go wrong or need adjusting, he was instructed to stop the machine and call a setter or the programmer.

The other machine was loaded automatically by means of a mechanical feed mechanism. Therefore, it did not need an operator as such, but did need someone to put new bars in and to monitor the machine. The person who did this also had responsibility for "minding" several automatic machines. As with the first CNC, if anything went wrong, he called a setter or the programmer.

Problems with CNC

The company's Managing Director had anticipated that problems might occur with programming and with setting the machine, and had carefully planned to avoid these. He envisaged that programming would be the main problem. He believed that the setters had neither the time nor the ability to programme, and that, therefore, a separate programmer with a good knowledge of mathematics was needed. He therefore made a draughtsman responsible for programming and proving. He was sent on a two-week course, and in addition the company spent £4,000 on a computer terminal, linked to a computer bureau, to assist with programming. In the event, this was not needed, because the programmer found that he could cope with the programming without the aid of a computer.

Two setters, the manager and assistant manager, were sent on a one-week setting course. They were chosen instead of other setters in order to ensure that those responsible for supervision knew as much as other shopfloor workers about CNC. At a later date the assistant manager, along with another setters, were sent on a two-week programming and setting course. In addition to this training, when the first CNC came into the factory, the supplier's engineer spent 8 weeks in the company giving additional training and advice.

Therefore, programming and setting were not, as such, a problem; however, finding an operator did prove difficult. When the first machine was installed, it alternated between bar work and manual loading and unloading of castings. It was envisaged that when an operator was required to load and unload, whichever woman operator was free would do it. However, the women operators did not like working the CNC. This was for two reasons:-

i) The women found working the CNC boring. As one of the setters put it:-

> All the women are used to working hard with their hands: loading, unloading, using their hands to work the machines. On the CNC, it's different; you just press a button.

ii) They were unhappy about pay for working the CNC. It was decided that, as the CNCs worked on a fixed cycle, it was impractical to put the operator on a bonus. This resulted in the operator of a CNC earning less than someone on piecework.

When the second machine was installed, it was decided that one would be dedicated to bar work and one to work that needed an operator. The machine-minding jobs were given to two male workers who had performed similar work on the automatic machines.

The one who worked the bar machine was paid an extra £3 on top of his basic pay, but the operator on the other was not. The male workers were chosen because the women workers would not do the jobs.

<u>The situation with CNC at the first set of visits</u>

At the time of the first set of vists, the two CNCs had been installed and working for 18 months and 6 months respectively. In the main, the machines were performing as well as the Managing Director could have wished - indeed, he declared that they were "peforming better than I anticipated".

There were, however, three problems with the CNCs:-

i) There was a dispute over the division of tasks between the programmer and the setters. It was the programmer's job to write the programs and to prove them out. This was a job he enjoyed; he saw it as a challenge, and together with his draughting functions, it gave him a varied and interesting job.

The setters, especially the assistant manager, on the other hand, pointed out that before CNC, they had been totally responsible for setting up machines and deciding on methods, and that they had greater machining experience than the programmer. For these reasons, they felt they should prove out programs, if not also, on occasions, actually programme. This caused friction between the programmer and the setters, as did the fact that they had previously enjoyed a high degree of autonomy, but now the programmer, who had been given an office in the machine shop, in their opinion, interfered in their work and tried to tell them what to do.

The result of this was that if the programmer went to one of the CNCs, he was immediately joined by one or more setters and vice versa. Also, when the CNCs were being set up and a program proved out, it was not unusual to see the programmer and three setters all "working" on the machine at the same time.

ii) There was also some concern over job losses. The order situation had not improved since the introduction of CNC; indeed, it may have worsened. However, the introduction of CNC had meant that work was transferred to them from the existing machines. This left those machines and their operators idle, and the operators were subsequently made redundant. This had led the programmer and the setters to argue that the CNCs should not be used to machine existing components but that the company should instead seek sub-contract machining work from other companies. They saw this as a way of keeping jobs and keeping the CNCs busy whilst not threatening existing workers' jobs.

iii) There was some doubt about the suitability of the CNCs for the work they were doing. A number of those connected with the CNCs had questioned the wisdom of using them for very large batches of simple components; they argued that newer types of traditional automatic machines would be more appropriate. The Plant Manager also argued that, in future, more of their products would be made from plastic and that this would reduce, if not eliminate, the need for machining.

Therefore, whilst the CNCs were performing well and whilst most people - both managers and workers - thought they were "fantastic", there were problems with them.

The situation at the second set of visits

When the final set of visits began in July 1984, a number of changes had taken place. Some had lessened the tension between the setters and the programmer, whilst others had cast further doubts upon the suitability of CNC.

The lessening of tension between the setters and the programmer was brought about by two events:-

i) The programmer spent less time with the CNCs because, by and large, he had programmed and proved out all the jobs that were likely to be produced on the CNCs. Therefore, there was less contact between him and the setters and less chance of friction, because the setters no longer felt he was watching them or trying to tell them what to do.

ii) The friction had mainly occurred between the assistant manager and the programmer, but the former, along with three operators, had been made redundant, and this appeared to have reduced some of the tension.

The changes that cast further doubts upon the advisability of CNC were twofold:-

i) The company had begun manufacturing a new pump which was made entirely from plastic. It did not need any CNC machining, and in addition was likely to reduce the demand for metal pumps.

ii) The company redesigned some existing metal pumps in order to reduce costs and simplify assembly, in the process of which the need for machining was further reduced.

Conclusion

A number of points arise out of this case study. The first is that, by and large, one person, the Managing Director, was responsible for the decisions to buy CNC and how it would be operated. However, in planning for its use, he appeared to have anticipated and overcome many of the problems regarding programming and involvement by supervisory staff that had arisen elsewhere.

This leads on to the second point, which concerns the formal and informal structure of the organisation, which, in this instance, appear to be almost the same. This is because if a problem arose with CNC, the machine shop foreman was trained to deal with it in the same way that he dealt with problems on conventional machines. This avoided the problem of his being bypassed and his authority undermined if operators continually had to seek someone else's advice. There had, nevertheless, been friction between the setters and the programmer, but at the time of the last visit, it seemed to be diminishing, and in any case did not appear to affect the structure of work.

The last point relates to the performance of the machines in technical, financial and human terms.

In technical terms, the machines were reliable but there was some doubt as to whether, given the large batches involved, CNC was appropriate. It may also be the case, given the company's move to plastic products, that investment in plastic injection moulding machinery, which they did not possess, would have been a better technical option.

The financial arguments are related to the technical ones. The management of the company was satisfied with the CNCs' output, but it may be that they would have been better rewarded financially with an alternative to CNC.

In human terms, in terms of the quality of jobs that were produced, the results were mixed. The programmer's job was varied, interesting, and had a high degree of autonomy. The setters, on the other hand, whilst liking CNC, felt that they had lost some of their traditional autonomy and technical superiority. The two "machine minders" both complained of the boredom and monotony involved in their jobs, but also pointed out that this was little different from their previous jobs minding automatic machines. The machine shop manager's job seemed little affected by the changes; he knew as much about the technology as the other setters, and did not appear to have suffered any reduction in his status or authority.

As a final comment, it appears that the introduction of CNC was well-planned and had achieved its objectives. However, it may be that the company would have been better served by investing in a different technology to CNC.

CHAPTER NINE

MEDIUM-SIZED COMPANIES

CASE STUDY FIVE

The Company

This is a medium-sized company which was founded in 1850 and remained independent until its take-over by a larger group of companies in 1958. Its main products are fluid control valves, which it supplies to a wide range of customers. Whilst the market for these products had diminished during the recession, the company managed to maintain its production levels and profitability by diversifying into new markets and by the introduction of new production methods. The latter were mainly responsible for the reduction of employee numbers from 300 in 1980 to 220 in 1984.

The firm's parent company exercises a high level of control over financial and marketing developments, but, with some exceptions, does not interfere in the day-to-day organisation and running of production.

Of the 220 employed, 80 were white collar and supervisory staff, and the remainder were ancillary and production workers. The main production departments were the foundry, the machine shop, and the assembly and testing department. The largest of these was the machine shop which, at the time of the first visit, employed 40 - 50 people.

This department, due to limitations of space, was located in two separate areas of the factory. Each had its own foreman who reported directly to the Production Manager, who was responsible for all aspects of production and assembly. At the time of the first visit, there was a machine shop superintendent who had the main day-to-day responsibility for this area, but he was subsequently promoted and his functions divided between the two foremen. There was also a Production Engineering Department which, amongst other things, was responsible for the programming of the CNC machines.

The company had 10 CNC machines, three of which were acquired after the first visits, which cost approximately £500,000. They were used to machine a wide variety of valves of moderate complexity in batches that could range from 10 to 1,000, but which tended to be between 100 and 300. Machining times averaged 5 minutes, though they could be as short as 2 and as long as 45. Set-up times were between 1 and 2 hours normally, but these times could be doubled when proving out a new program. There were some 2,000 programs for the CNCs, and this figure was constantly being added to. It took approximately 3 hours to write each program.

The first set of visits to the company began in April 1984, and the last visit took place in January 1985. Initial contact was made with the machine shop superintendent.

Management-worker relations within the company at the time of the first visit appeared friendly, especially in the machine shop, but, for reasons explained below, these deteriorated later.

Most of the shopfloor workers belonged to a trade union, but the unions did not appear to be active or even well-regarded by their members, and had certainly taken no interest in the introduction of CNC.

The organisation of work before CNC

Before CNC was introduced, the company employed 90 to 100 people in machining activities, some of whom were on a separate site altogether. The workers were split into three groups: setters who set up automatic machines and who were considered the most skilled; operators, mainly female, for the automatic machines, who were the most numerous and least skilled group; and a small number of conventional machinists who were nearer the setters than the operators in terms of skill. The setters were each responsible for setting a group of 3 or 4 similar machines. The operators invariably worked the same machine all the time, producing the same narrow range of work; this was also the case for the conventional machinists.

Supervision was organised on the same lines as at the time of the study, with each section having its own foreman. All the shopfloor workers were on a piecework bonus system, with the setters being paid in relation to the output of the operators on the machines they set up.

The reasons for introducing CNC

At the time of the first visit, the company had 7 CNCs, the first two of which were installed in 1976 at a total cost of £125,000. The decision to buy the first two CNCs was taken, without consultation, by the parent company, and it is still not clear why the machines were bought. The generally-accepted view was that the parent company were buying two CNCs for another firm within the group and found that they got a much better deal for four than for two.

Whether this was the real reason or not, the outcome was that they were told to expect two CNCs for which they were totally unprepared, given that they had previously not considered using them.

Despite this, and despite severe problems getting the machines fully into production, the company gradually became convinced that CNC was vital to their future, and between 1980 and 1983 bought another 5 CNCs. The Production Engineering Manager and the machine shop superintendent became jointly responsible for assessing and justifying the need for further CNCs. They had to prepare a detailed report of the reasons for each new purchase, which had to be approved by the parent company.

The main justifications for the additional CNCs were:-

i) The existing automatic machines were only economical when producing batches over 1,000; some were only economical on batches of 5,000 or more. However, batch sizes on many products had fallen far below these figures. The advantage of CNC was that whilst their production rate was no faster than automatic machines, they were faster to set up. An automatic machine could take 4 or 5 days to set up, whilst a CNC could be set up in 3 or 4 hours at the most.

ii) Some products required machining on 5 or 6 different machines, with 5 or 6 different set-ups. It was found that many of these could be done at one set-up on a CNC. In many instances, this not only cut setting times but also cut production times.

The result of this was that both those involved in production and production engineering became firm advocates of CNC. However, CNC introduction did have one drawback: the same amount of work could be produced with far fewer people. In the main, it was the female operators who lost their jobs, with the male setters becoming setter-operators on the CNCs. Whilst most regretted the loss of jobs, the general view was that it was necessary if the company was to stay in business.

The organisation of work around CNC

For a variety of reasons, it took the company a year after the introduction of the first two CNCs to arrive at a settled form of work organisation. The form finally adopted was that a programmer, a former work study engineer, would write the programs and prove them out in conjunction with a setter-operator who did the rest. As more machines were purchased, the programmer had less time to spend proving out, and gradually, apart from rare occasions, the setter-operators came to perform this function alone.

However, as more machines were purchased, not all had their own setter-operators. Three machines were set up by one setter, who was assisted in operating the machines by one person classed as an operator. This was done for three reasons:-

i) Only one of the machines required loading by hand; the other two were bar feed machines. This meant that whilst one machine needed a full-time person to load and unload, the other two could be watched by one person.

ii) The machines were very similar and it was possible for one setter-operator to become conversant with them all.

iii) The machines tended to be used to produce larger batches than the other CNCs, and therefore did not require setting up as often. This allowed one setter to be able to cope with setting three machines.

Therefore, by 1983 when the company had 7 CNC machines being operated on two shifts, the situation was that there were ten setter-operators and two operators.

Supervision of the CNCs was provided by a foreman, who had spent three months learning programming with the programmer, and the superintendent, who was also familiar with CNC. They were responsible for all matters concerning CNC, though if programming problems occurred which neither they nor the setter-operators could solve, then the programmer would be called upon.

The problems with CNC

The main problems that the company experienced with CNC occurred within the first 12 months, and revolved around the role and payment of those responsible for setting and operating the machines. There were two other lesser problems; one being the resentment of the Production Engineering Manager that he had not been consulted about the purchase of the machines, and the other being that whilst one machine was installed in the company's main building, the other was located in an annexe to the main factory some ½ a mile away.

The latter caused delays and problems on both sites with the programmer, at least at the beginning, having to make 5 or 6 trips between the sites each day. This was not resolved until the annexe was transferred onto the main site in 1979/80. It is more difficult to assess the impact of the former problem; however, it was significant that, even four years later, the Production Engineering Manager, to whom the programmer was responsible, was still highly critical of the decision to buy the first two CNCs without consulting his, or anyone else's, department.

Nevertheless, the main problem revolved around the setting and operating of the CNCs. The company decided that both machines would be run by setter-operators and that the programmer would prove out new programs. However, on the main site, the setter-operator, who had been an existing setter with some CNC experience, left - or was fired - after only one month. The company then made one of the setters for the automatic machines responsible for setting the CNC as well, with a separate operator being employed to load and unload it. This also proved problematic, in that there were a number of accidents on the CNC, and to avoid these, the setter was faced with spending more time on the CNC, and leaving the automatic machines standing idle because he did not have time to set them up, or leaving the CNC idle for the same reason. This affected the earnings of the setter and the operators on the automatic machines and the CNC, whose pay was linked to output. Eventually, the CNC operator left and the company made the setter into a setter-operator.

The situation was worse on the other site where, to quote the Production Engineering Manager, "we went through 6 setter-operators in 6 months because we couldn't get the right people".

The difficulties on both sites appeared to be caused by two main factors:-

i) There was a dispute, between some - if not all - of the setter-operators on the one hand and the programmer and the Production Engineering Manager on the other, as to who should do what. The latter wished to prescribe methods of production and keep the input of the setter-operators to a minimum, whilst some of the setter-operators felt they should have a greater involvement. As the foreman put it:-

> We had one chap who'd worked CNC at another place . . . and he just held the company to ransom. He wanted the methods and set-ups done his way.

ii) The setter-operators felt they should be paid more for working CNC. This was compounded by the fact that it is difficult on a fixed cycle machine such as a CNC to earn bonus, and also, if a problem arises and the machine is stopped, bonus is lost. Therefore, rather than being paid more, the setter-operators could actually earn less, in which case their demands for higher pay were not surprising. However, the company's management saw the request for more money as a threat. To quote the Production Engineering Manager:-

> We had to dig our heels in when they said "pay us more or we leave". Until we did that we were on a hiding to nothing; we couldn't get co-operation, we couldn't get respect, because all they could think about was how they could screw us for more money.

It took the company 12 months from the installation of the machines before a settled pattern of work organisation emerged and the various problems were resolved. Four changes contributed to the improvement of the situation:-

i) The setter-operators whom the company saw as troublesome either left or were fired, leaving the way clear for others to take their place.

ii) The company trained more setter-operators than it had machines for in order to protect themselves from being "held to ransom" by people whose skill could not easily be replaced.

iii) The output bonus for setter-operators was replaced by a fixed bonus which ensured that they did not lose money by working CNC.

iv) The programmer came, gradually, to involve the setter-operators more and they eventually were given full responsibility for proving programs and were consulted on production methods.

After this, it became policy when buying new CNCs to ensure that setter-operators were fully trained and conversant with them. Indeed, not only did setter-operators receive training in setting and operating the machine, but many of them also spent 2 or 3 months working with the programmer to learn how to programme the CNCs as well.

The result was that, after a somewhat disastrous first 12 months, those involved with CNC came to see themselves as a team who worked well together. To quote the foreman:-

> I've a lot of time for these chaps who work on CNC and I hope it would be reciprocated, because from the programmer, through the superintendent, through me, and to the setter-operators, we have tried to make the section into a team . . . and if you ask anybody on this section, they'd say they were reasonably happy with this set-up.

The situation at the first set of visits

The first set of visits began in April 1984, and the situation was as described at the end of the last section. The setter-operators and the two operators liked working for the company and enjoyed working on CNC. There was also a strong impression of teamwork. However, not all were happy with the organisation of work.

The Production Engineering Manager wished to move away from the setter-operator system:

> We now have three machines worked by one setter-operator and one operator. That's the way I see it progressing.

He felt that this method would be cheaper and utilise the setter-operators' skills more. The machine shop superintendent took a similar view:

> We train them [setter-operators] and pay them for a skill they use only 15% of the time.

He wanted to see the setter-operators formed into a pool of setters who could be called upon to set any CNC whilst the actual operating of the machines would be done by other people. He had not been able to move to this system because of the "low number of CNCs". However, he said that this situation would change:-

> No one here [on the shopfloor] knows this, but we shall be bringing in approximately 5 more CNCs. I've got the overall responsibility for transferring products and equipment from one of our Scottish factories [which was being closed down] to here. I've looked at our manning levels and I'm determined that we shall remove the setters from operating the CNCs and they will work in what we call a setting pool. All the CNCs will be put into the pool and the setters will set them up and then hand them over to an operator.

An added advantage of this system, from the superintendent's point of view, was that the operators could be put on an output bonus system which, he believed, would motivate them to work harder and thus increase output.

The transfer of machines was due to take place the following October, when the new system would be introduced. Therefore, arrangements were made to re-visit the company at that time.

<u>The situation at the second set of visits</u>

Due to the pressure of work involved in transferring the plant and equipment into the existing factory, the second set of visits could not be accommodated by the company until January 1985, and by this time a number of changes had already taken place.

One change was that the machine shop superintendent had been promoted to Production Control Manager, and had no responsibility for the machine shop. Rather than replace him, the company had upgraded the two existing foremen, who took on his functions and were left to carry out his re-organisation plans. In addition, two working charge hands were appointed for the CNC section, one for each shift.

However, the main change, as anticipated, was the re-organisation of the setting and operating functions on the CNC section. The transfer of equipment had brought 3, not 5, extra CNC machines into the company, thus making a total of 10 in all. For these 10 machines there were, on each shift, 5 setters, who also did some operating, and 4 people who were purely operators. It had been the ex-superintendent's plan that the setters would operate as a pool and would be called upon to set, but not operate, any of the 10 machines. However, this did not occur, and instead the CNCs were split into 3 groups: there was one group of 4 machines that were set up jointly by 2 setter-operators who also, along with 2 operators, operated the machines; a group of 3 machines which were set up by 2 setter-operators who also, along with a further operator, operated them; and *another group of 3 machines which* were set up by one setter-operator who also, along with another operator, operated the machines. This last group was the one that was in existence at the time of the first visits. In terms of pay, the setter-operators were paid as before, but the operators' pay was related to output.

This form of organisation, as opposed to that previously envisaged, emerged for three reasons:-

i) It had been anticipated that there would be 12 CNC machines and that these would provide enough work to keep 5 setters fully occupied without also having to operate the machines. With only 3 additional machines being introduced, this was no longer the case, and if the setters had no longer been involved in operating the machines, there would have been periods when they had nothing to do.

ii) The setter-operators objected to being asked to set up all of the 10 machines. They felt that it was not practical to ask them to set up more than 3 or 4 different machines efficiently. As one setter-operator put it:-

> You can actually learn to set up all the machiens, but you can't spend enough time on them to get fully conversant. If they keep flitting you from machine to machine, you're never going to learn them properly, and that means you go on them and make mistakes every time.

iii) The company wanted the new machines in operation, and the new products being produced, in a matter of weeks. This meant that there was little time to train setter-operators on machines that they were not familiar with.

Consequently, the company had to settle for a modified system of CNC organisation. However, even this was not without its problems.

i) Whilst the setter-operators, in the main, preferred setting to operating, they were not happy that they had not been consulted about the changes. In addition, they believed that they should receive more pay because they were doing more setting. To quote one setter-operator:-

> *They called* us into the office and said, "That's what's happening", and of course it backfired on them because we all kicked up against it. We finally agreed to work the modified system on a trial basis, but it [pay] is still to be sorted out. If they don't come up with some more money then we might go back to the old system.

ii) Setting times and the time that machines were standing idle had increased. This was for three reasons:-

a) On occasions, all the machines in one group might need setting at the same time. This meant that some machines had to wait whilst others were set up.

b) The setters were not all fully conversant with the machines they had to set and, therefore, took longer than they otherwise would.

c) The setters could be called away from a setting job to deal with an operator's problem.

iii) Production times had also increased, for similar reasons:-

a) If an operator had a problem, he had to fetch a setter, whereas before, the setter-operator would have dealt with it immediately.

b) When a setter was actually operating a machine, he could be called away and the job he was doing could be left waiting.

iv) The operators were also upset about their pay. They were paid in relation to output, but, for the reasons mentioned above, they could often not be producing because they were waiting for a setter. In addition, as mentioned earlier, it is difficult to earn bonus on CNC.

In addition to these problems, there was some disquiet by those who initiated and supported the changes about the way they were working in practice.

The ex-supervisor still believed that a full pool system should have been introduced rather than the modified one, and that if this had been the case, there would have been fewer problems. On the other hand, the Production Engineering Manager, after seeing the system in practice, no longer supported the idea of separate setters and operators. He believed now that it was too much to ask setters to set up ten different machines, and he was worried about the longer setting and production times.

Therefore, almost no one was happy about the changes that had taken place, but now that they had taken place, no one appeared to be in a position to alter the situation. This meant that it was left to the setter-operators, the operators, and the two foremen to make the best of a system that they had had no say in introducing.

Conclusion

A number of points arise from this case study. The first point is that the company's early problems with CNC were caused by two factors:-

i) The general lack of readiness of the company for CNC;

ii) The clash between the Production Engineering Manager/ programmer and the setters/setter-operators over allocation of work and levels of pay. This may have been exacerbated by the resentment felt by the Production Engineering Manager about not being consulted regarding the purchase of the CNCs.

The second point is that the re-organisation of work that took place prior to the second set of visits once again met opposition from the setter-operators and once again raised issues of who should do what and how much they should be paid.

The third point is that the re-organisation of work was brought about, mainly, by one person, the Machine Shop Superintendent, and was justified on the grounds that it would reduce costs, by allowing lower-paid workers to operate the machines, and increase productivity, by linking pay to output.

The fourth point is that, up to the second set of visits at least, the formal organisation of work and the actual organisation were the same. This was brought about by fully involving and training supervisory staff in CNC.

The final point concerns an assessment of the performance of CNC in technical, economic and human terms.

In technical terms, there appeared to have been few problems with the machines.

In economic terms, after the initial problems and up to the second set of visits at least, the CNCs appeared to have more than justified their purchase. This was confirmed by the fact that the parent company carried out post-installation assessments on all new machines, and these showed the CNCs as being economical. However, after the first set of visits, the situation changed; production and setting times increased due to the organisational changes.

In human terms, excluding the first year of CNC, the situation up to the second round of visits appeared to have been very good for the setter-operators. They received full training and were expected to carry out a wide range of activities up to and including proving programs, and they all expressed the view that they enjoyed their jobs. However, this was not so for the operators of the automatic machines, who were mostly made redundant. The setter-operators' position changed with the re-organisation of work at the time of the later visits. They became dissatisfied with the lack of consultation, with being expected to set up a wide variety of machines, and with their pay. The new operators were also unhappy, in that their job was both boring, in that they were only loading and unloading, and frustrating, in that they had to fetch a setter every time any adjustment was required. They were also dissatisfied with their pay.

The changes also affected the foreman in that he found himself having to cope with the problems of a re-organisation that was not of his making. Nevertheless, he enjoyed his job and found it was made easier due to the programming training he had received. The programmer also enjoyed his job, and whilst many of the CNCs had different programming languages, he appeared to cope with this well, rather than finding it a source of frustration. However, he was concerned about the problems brought about by the re-organisation.

Therefore, whilst the organisation of work up to the second set of visits was satisfactory in economic and human terms, the situation deteriorated from then on. This could be a temporary phenomenon that would disappear over time, as people became accustomed to the new system; on the other hand, the situation could deteriorate further, as all concerned became more frustrated with the problems that had arisen. At the time of writing, it was impossible to say which would be the case,

CASE STUDY SIX

The Company

This is a medium-sized company, which is a subsidiary of an American firm and was established in 1963. Its main product is steel and plastic strapping which is used for holding together anything from small parcels to very large crates. It also manufactures the machines for applying the strapping; the company's CNCs are used to manufacture parts for these machines.

The company employed approximately 250 people at the time of the study, of whom 50 were in the Machinery Division. Day-to-day control of production was the responsibility of the Production Manager, who was assisted by a foreman. The Engineering Department, which was responsible for programming CNC, was run by a separate manager.

The company had been badly hit by the recession; its market had shrunk by 40%, which had led to a commensurate level of redundancies, and for the past 3 years it had only managed to break even financially. In order to cut costs, the Machinery Division, originally located in London, was moved in 1981 to South Yorkshire, to the same site as the rest of the company.

The Division was split into two sections: the machine shop, which employed 24 shopfloor workers; and the assembly shop, which employed 8. The machine shop had two CNC machining centres bought in 1978 and 1981, before the move, and costing approximately £60,000 each. They were used to manufacture a wide range of high-precision machine parts in batches ranging from 30 to 200, with the average being approximately 100. Machining times ranged from 10 to 50 minutes, with the latter tending to be the norm. It took 8 to 10 hours to set up each machine and an additional 4 to 6 hours to prove new programs. Preparing new programs could take 5 hours to 3 days; there were 130 existing programs, and new ones were constantly being made.

Only one set of visits was made to the company, and these were in July and August 1984. The initial contact was made with the Engineering Manager.

Management-worker relations within the Machinery Division, whilst not being hostile, were not friendly either. The main reason for this appeared to be the uncertainty caused by the redundancies and the company's financial situation. This was probably compounded by the fact that most of the employees were new to the company; all except 5 or 6 of those employed in London had chosen not to move.

Most of the workforce were unionised, but the union was not particularly active and appeared to view such matters as redundancies and wage increases as out of its control.

The organisation of work prior to CNC

The components now manufactured on CNC were previously made on a variety of milling and drilling machines. In addition, there were a number of conventional and automatic lathes, which were still present at the time of the visits. The machine shop was under the supervision of a foreman, assisted by a supervisor; the latter was also responsible for setting certain automatic machines. There were at least 5 different skill levels on the shopfloor: setters for automatic machines; different setters for semi-automatic machines; setter-operators for semi-automatic machines; operators for automatic and semi-automatic machines; and conventional machinists. The tendency was for them to be limited to a small number of machines or types of work.

The company operated an individual bonus system based on output, which applied to all shopfloor workers. When CNC was introduced, the system was applied to those machines as well.

The reasons for introducing CNC

The Engineering Manager was responsible for recommending the purchase of new equipment. He had to prepare a rigorous justification for each purchase, whch had to be approved by both the British and American Boards of Directors. He recommended CNC for 3 reasons:-

i) Many of the components required 20 to 40 separate machining operations, which could involve a different set-up for each operation. On CNC, all these operations could be done at one set-up, and thus achieve a great saving in set-up time.

ii) CNC is quicker, and therefore the same work could be done by fewer people.

iii) On the previous machine, expensive jigs and fixtures were required. This was not the case with CNC.

These were the main reasons for buying the first CNC and, when this had proved itself, the second CNC as well.

The organisation of work around CNC

When the Machinery Division was located in London, a production engineer in the Engineering Department was given the responsibility for programming the CNCs and for setting them up; in this latter respect, he was assisted by the machine shop supervisor. Each machine had a separate operator who was responsible for loading and unloading the machine, but if any problems arose, they would call the supervisor, who in turn might call the programmer. This method of operation appeared to have been chosen because it resembled the organisation of work on the existing automatic machines.

However, when the Machinery Division moved to South Yorkshire, this changed. A new programmer was appointed who did not set up the machines, and the supervisor, who was promoted to foreman, also ceased to perform this function. Gradually the company moved to a system of having a setter-operator for each machine who, along with the programmer, proved out.

The problems with CNC

It was not clear what problems, if any, there were with the CNCs when they were located in London, but a number arose when they were moved.

The first was that most of the employees, including the programmer and the CNC operators, did not move from London. Therefore, the company had to recruit new people for these and many other posts. However, they could not find a suitable programmer in South Yorkshire, but eventually, with some difficulty, they managed to recruit a very experienced one from the West Midlands.

It was the intention that the new programmer, along with the supervisor who had now become foreman, would set up the machines as before, but a variety of problems prevented this. These were:-

i) The foreman and the programmer disagreed about programming and setting methods; indeed, the programmer began to re-write all the existing programs. Eventually, the foreman, who in any case had more calls on his time than was previously the case, ceased to be involved with the CNCs.

ii) When the company moved, the number of production engineers was reduced from 4 to 2, which meant that the programmer had less time to devote to the CNCs.

iii) The programmer believed that a system of setter-operators was the most economic and effective way of running CNCs. This was because they could sort out most problems immediately without having to call other people.

iv) The programmer felt that if he set up the machines, it would lower his status.

These problems were eventually resolved when the programmer persuaded his superior, not without some resistance, that a setter-operator should be trained to set up both, and operate one, of the CNCs. The other would be operated by whichever automatic machine operator happened to be free when the CNC needed an operator.

This suited the programmer, who spent less time on the shopfloor as a result. It also meant that problems were sorted out much quicker. However, two further problems did arise: there was not always a spare operator free to work the other CNC, which could sometimes be standing idle until one became free; and when the setter-operator was setting up one machine, the other was standing idle, which effectively doubled the setting time on both machines. Therefore, the programmer persuaded his superior that a second setter-operator should be trained.

The result of this was that each machine had its own setter-operator who, together with the programmer, also proved out new programs. The setter-operators were still on a bonus system, but it appeared to have been modified to the extent that their bonus was almost guaranteed. The foreman, however, was no longer involved in CNC, and to all intents and purposes the setter-operators were responsible to the programmer.

The situation at the time of the visits to the company

The only change from the situation outlined above was that the first setter-operator had left, to take up a better job, and a new one was being trained. Nevertheless, the programmer was so pleased with the setter-operator system that in future he intended to let them prove the programs by themselves and perhaps even to do some programming as well.

The only other development was that the company were examining the feasibility of buying more CNCs, especially lathes. However, this was seen as being some time away, given not only the company's financial position but also the lengthy process required to obtain approval for expenditure on new machinery.

Conclusion

A number of points arise from the case study. The first is that whatever the merits and demerits of how CNC was organised in London, the move to South Yorkshire, and especially the change of personnel, brought about significant changes. These were closely associated with the new programmer, who believed that it was in the company's - and his own - best interests to move to a system of setter-operators. He was eventually successful in bringing about change, but in the process he had to gain the support of his superior, the Engineering Manager, and overcome the resistance of the foreman. In the case of the latter, this resulted in his withdrawal from CNC involvement altogether.

The second point follows on from this. In London, the formal organisation of work and the actual organisation were the same. This was because the then supervisor was fully involved with CNC. However, the situation at the time of the study was that whilst he was formally still in charge of CNC, in practice the programmer was now responsible for all aspects of CNC. Therefore, the formal and actual organisation of work had diverged.

The final point concerns the performance of the CNCs in technical, financial and human terms. In technical and financial terms, there appeared to be few problems with the CNCs, and the company's management appeared sufficiently satisfied to contemplate buying more CNCs.

In human terms also, the CNCs had now proved satisfactory. The setter-operators had a responsible and varied job, which was being improved by the addition of responsibility for proving, and in the future, perhaps, even writing new programs. The programmer had improved his job by relieving himself of the setting function, which had allowed him to become more involved with the other activities of the Engineering Department. Even the supervisor had not lost out, in that he now had more time to devote to his new role as foreman.

Therefore, this is a case where a change of personnel resulted in a significant change, and in human terms at least improvement, in the way CNC was organised.

CASE STUDY SEVEN

The Company

This is a medium-sized company which was established in Britain by its American parent company in 1935. The company has two main product ranges: drill chucks, and engineers' tools such as drill sleeves and revolving lathe-centres.

The company employed 150 at the time of the study, which was 600 less than were employed in 1981. The fall in numbers was entirely due to the recession, which had obviously affected the company particularly badly. Of those currently employed, some 40 were staff and the remainder were shopfloor workers who were evenly split between the section producing drill chucks and the section producing engineers' tools.

Each section had its own supervisor who was responsible to the Production Director, who was in day-to-day control of production. Both sections were located in the same building, side by side. There was also a small Production Engineering Department which, as well as being responsible for production methods, quality and work study, was also responsible for CNC programming.

The company had one CNC lathe which was installed in October 1984 at a cost of £55,000. It was used to produce medium-precision engineers' tools in batches ranging from 50 to 500, though the average batch was approximately 200. The machining time per component was between 2 and 6 minutes, and set-up times could range from one to 4 hours. In addition, proving out new programs could take 2 to 3 hours, whilst writing them took 3 to 4 hours. At the time of the last visit, there were some 50 different programs, and it was envisaged that this figure would eventually rise to 200.

The first visit to the company was in July 1983, some 3 months before the CNC was installed, and the last visit was in February 1985. The initial contact was made with the Production Engineering Manager.

Management-worker relations within the company were very friendly, though this had not always been the case. When the company employed 750 people, there were, apparently, frequent industrial disputes and much unrest. With the fall in numbers, relations had significantly improved; managers connected this with the fact that the trade unions, whilst still being officially recognised and formally consulted, did not appear to be particularly active.

The situation at the first visit

The first visit to the company took place in July 1984. Therefore, what follows is a description of the organisation of work and the company's view of CNC before the machine was installed.

The organisation of work prior to CNC

The majority of machines in the workshop were automatic or semi-automatic machines. In the main, there were two types: purpose-built automatic machines designed to produce a small range of components in batches ranging from 6,000 to 60,000; and standard automatic and semi-automatic machines that were used to produce batches ranging from 1,000 to 6,000. The latter tended to be used for producing engineers' tools, whilst the former were used exclusively for drill chucks.

There were two basic shopfloor jobs, namely setting and operating. These were graded, using a very elaborate job evaluation method, from Grade 1, the most skilled setter, to Grade 6, the least skilled operator. Each person had a detailed job description which specified their exact duties. All operators, and those setters on Grade 3 or below, were on an output bonus system.

The reasons for introducing CNC

The Production Engineering Manager, in consultation with the Production Director, had primary responsibility for assessing the potential of and recommending CNC. The original proposal, backed by a very detailed financial justification, was agreed by the British Board of Directors in 1980. However, owing to the company's financial position, it was not until 1984 that the American Board gave permission for the purchase.

There were three main reasons why the company wished to purchase CNC:-

i) Due to the recession, batch sizes on many engineers' tools had fallen to below 1,000, some to as low as 50, which meant that it was uneconomic to produce them on their existing automatic machines. A detailed study showed that substantial savings, especially in set-up times, could be made by manufacturing them on CNC.

ii) Most of the existing machines were over 10 years old and the cost of maintenance for them was very high. A new CNC would allow some of these machines to be scrapped and thus reduce overall maintenance costs.

iii) The company felt that it needed to acquire new technology or it would be left behind. To quote the Production Engineering Manager:-

> . . . we need to get into new technology . . . which I think is the way we've got to go. We've got to get into the learning process.

These were the reasons why the company had ordered a CNC, which was due to be installed in October 1984.

<u>The proposed organisation of work around CNC</u>

It was the Production Engineering Manager's intention that a production engineer would be responsible for programming and setting the machine, and that an operator would be employed to load and unload the machine and to monitor, and perhaps adjust, the machine during production. In fact, two operators were to be trained so that it would eventually be possible to work the CNC on two shifts. However, this could not take place until other machines were also on two shifts, which was considered unlikely in the near future. This form of organisation was favoured for three reasons:-

i) Existing automatics had separate setters and operators and it was felt that this would work equally well on CNC.

ii) A production engineer was to be given the programming and setting tasks because it was felt that these were best carried out together, and that a shopfloor worker would not have the necessary ability to programme.

iii) The Production Engineering Manager wished to have a personal involvement in, and supervision over, programming and felt that this would be best achieved if it was done by someone directly responsible to him. There were two production engineers and it was envisaged that both would eventually be trained to programme and set.

This, therefore, was the position before CNC was installed.

The situation at the second set of visits

The next set of visits commenced in November 1984, some three weeks after the machine had been installed. The CNC was in production, but only on a trial basis whilst those involved got used to the machine. The organisation of work was not as had originally been envisaged. Instead, a production engineer was programming the machine, but two setter-operators were actually setting it up and operating it. In addition, with the programmer, they were proving out the new programs. The production engineer felt that the setter-operators would eventually prove out by themselves and might even come to do some programming as well.

This change from what had previously been envisaged was for two reasons:-

i) The machine suppliers had advised the company that having a production engineer to programme and set up the machine would be inefficient. This was because the production engineer, who had many other duties, might not always be available to set up the machine or sort out problems, which would lead to it standing idle when it should be producing.

ii) The production engineer felt that he had neither the time nor the experience to set up the machine. He also viewed setting as a shopfloor function and felt that his status would be lowered if he did this.

Therefore, two existing setters were selected as setter-operators for the CNC. After the trial period, it was intended that they would work alternate weeks on it until such time as the machine was put onto two shifts. They were to be classed as CNC Technicians and paid at Grade 1 rate; for one of them, this was an increase as he had been on Grade 3, but the other was already on Grade 1. The introductory process was going smoothly and all concerned were pleased with it; however, there were some problems, which were as follows:-

i) The production engineer, who was responsible for CNC introduction, and the Production Engineering Manager had both been on a one-week training course for programmers, of which they were highly critical. They were also critical of the training given to the setter-operators by the installation engineer, though the setter-operators themselves were not.

ii) The Production Engineering Manager had decided to pay the setter-operators at Grade 1; however, this would eventually have to be confirmed, or not, by a full job evaluation. He was worried that the evaluation method might not be able to accommodate CNC and would recommend a lower grade, which would obviously lead to problems with the setter-operators. If this should be the case, the Production Engineering Manager, who was a member of the Job Evaluation

Committee, felt he could get the decision overturned, but was unhappy at the prospect of having to do so. He was also worried about another pay-related problem: bonus. He, and the production engineer, believed that they would only get full output from CNC if the setter-oeprators were put on a bonus scheme, but there was no provision for Grade 1 workers to be on bonus, and it was not clear how this would be achieved.

iii) The production engineer did not like using the tape preparation machine, a device similar to a typewriter, and chose to input the programs manually into the CNC. Whereas to feed a paper tape into the CNC would take approximately 1 minute, it would take some 20 - 30 minutes to input the same information by hand. Therefore, the CNC was standing idle for longer than would have been necessary if the tape preparation machine were used.

iv) It was intended that the supervisor would receive CNC training, but during the introductory period, he was not being involved at all, and no-one was sure when he would receive his training and become involved.

However, despite these problems, everyone was pleased with the progress that had so far been made in introducing CNC.

The situation at the third set of visits

The last set of visits commenced in February 1985, and by this time the CNC was in full production. To a large extent, there was general satisfaction with the progress made; the company were already beginning to think of buying a second CNC, but there were some problems, which were:-

i) Whilst the CNC was now producing at the anticipated rate, the production engineer and the manager felt that this could be increased by 20% - 30% if the setter-operators were put on bonus. They felt that unless their pay was linked to output, the setter-operators would not voluntarily produce more. However, the company had still not devised a bonus scheme for Grade 1 workers, nor had time studies been carried out. The former was the responsibility of the Production Director, who had stated that it would be done when the time studies were completed. The latter were the responsibility of the Production Engineering Manager, who could not see the point in doing time studies until a bonus system had been devised. Therefore, whilst he wanted a bonus system to be introduced, he was also partly responsible for blocking its introduction. It was also the case that before a bonus system could be introduced, a full job evaluation, with its potential problems, would have to be carried out.

ii) The supervisor had still not been given any CNC training and was therefore still not involved with CNC. In the interim, his supervisory functions were being carried out by the programmer.

iii) The setter-operators felt that, in retrospect, they had not received enough training on the programming aspects of CNC, and that this was slowing down their participation in proving out programs and sorting out problems.

iv) The system of the setter-operators alternating on a weekly basis between CNC work and other work had broken down. This was because one of the setter-operators had to take the place of a colleague who was ill, and did not work on CNC for 5 weeks. When he finally got back on CNC, he had to re-learn much of what he had been taught. It appeared that this could happen frequently with both operators, and would not be resolved until both were required to work on CNC full-time.

v) The production engineer was still continuing to input programs manually, and had abandoned all pretence of using the tape-preparation machine.

Despite these problems, there appeared to be no doubt that the company saw CNC as a good investment and that those involved with CNC preferred it to the previous arrangements.

Conclusion

A number of points arise from this case study. The first is that the Production Engineering Manager, who was responsible for CNC introduction, had to change his original intention for CNC organisation in the face of advice from the CNC supplier and opposition from the production engineer. This indicates that whilst he appeared to have fully investigated the technical and economic aspects of CNC, the organisational ones had received less attention.

The second point relates to the formal and actual organisation around the CNC. Formally, the supervisor was in charge of production from the CNC, but in practice this role was being carried out by the production engineer, and, at the time of the last visit, there was no indication of whether, and if so when, this would change.

The third point relates to the performance of the CNC in technical, economic and human terms.

In technical terms, there appeared to be few, if any, problems with the machine.

In economic terms, the machine had measured up to its promise; indeed, the Production Engineering Manager felt that this could be substantially improved when a bonus system was introduced.

In human terms, the outcome appeared to please the production engineer, who enjoyed programming and the added prestige of working with new technology. The setter-operators, despite one or two problems, preferred CNC to their former jobs and welcomed the chance to be involved with new technology. Whether this would change if a bonus system were introduced remained to be seen, but both would welcome one because they felt that they would earn more money. The only person who might lose out by the introduction of CNC was the supervisor, if he did not become involved in this or future CNCs.

CHAPTER TEN

LARGE COMPANIES, LARGE BATCHES

CASE STUDY EIGHT

The Company

This is a large company, comprising four separate factories, which is the biggest overseas division of an American multi-national corporation. It was established in Sheffield in 1936 and is market leader in the production of high quality hand tools such as woodplanes, screwdrivers and hammers.

The factory where the CNCs have been introduced employed 800 people at the time of the study, and was also the headquarters for the other three factories. In 1979, the company's four factories employed 2,000 people, but because of a decline in its market - turnover dropped from £30 million in 1979 to £20 million in 1981 - by 1983, it only employed 1,200. Despite this, the company has never made a loss and in 1984 made £3.8 million profit.

The recession led the American parent company to rationalise its American and European operations, which resulted in a reduction of the operating independence the British company had previously enjoyed. Though this did not, as such, affect day-to-day control of production, it did lead to a transfer of some products from Sheffield to factories in other countries and vice versa.

The four factories were run by a production controller, responsible to the British Board of Directors, and each had its own Factory

Manager, who was responsible for production on a day-to-day basis. At the factory where CNC was introduced, the manager is responsible for the shopfloor and supervisory staff as well as various ancillary technical functions.

The CNCs were installed in the Plane Department of the main factory, which had 90 employees and was split into 3 sections, each with its own supervisor. The supervisors were responsible to a departmental foreman, who in turn reported to the Works Manager. There was also an Engineering Department, responsible to the Works Manager, which, amongst other functions, was in overall charge of CNC programming.

At the time of the first visit, the factory had 2 CNCs; it later acquired a third. The two CNCs were both milling machines, bought for approximately £20,000 each in 1979 and 1981 respectively. They were used to perform simple milling operations on a small range of woodplanes which ranged in batch size from 700 to 10,000, though the normal batch size was 1,000. Machining time per plane was between 30 and 60 seconds, and set-up time ranged from one hour on the second CNC to 4 hours on the first, which performed slightly more complex operations than the other machine. There was also a difference in the time to write and prove programs: four hours on the second machine and one to two days on the first. However, the machines only had 12 programs each and new ones, at the time of the first visit, were quite rare.

The first visit took place in January 1983 and the last one in October 1984. Initial contact was made with the Engineering Manager.

Management-worker relations in the company appeared very friendly, and a high proportion of the workforce, especially the men, had been with the company since they left school.

The company was unionised and the unions were active in a wide range of joint management-union committees. They did not have a record of militancy; they accepted the redundancies as inevitable, and their interest with regard to the introduction of new equipment revolved around payment rather than job content.

The organisation of work prior to CNC

The operations carried out in the Plane Department were the milling, drilling and tapping of woodplane bodies. These had been, and still were to a large extent, performed on a range of semi-automatic and conventional machines which were limited to carrying out a small range of similar operations. There were three basic machine-related jobs: setting semi-automatic and conventional machines; setting and operating conventional machines; and operating semi-automatic and conventional machines. The setters were classed as skilled workers; the setter-operators as semi-skilled; and the operators, some $^{2}/_{3}$ of the Department, were also classed as semi-skilled, but were paid at a lower rate than setter-operators. Pay was determined by a job evaluation system and each worker had his/her own written job description: there were 46 different grades of shopfloor worker. All the operators and setter-operators were on an individual bonus system; this continued to be the case with CNC personnel as well. Supervision, which was close, was provided by three supervisors who were responsible to the departmental foreman.

The reasons for the introduction of CNC

Part of the parent company's rationalisation plan involved the introduction of newer production methods and equipment in order to reduce costs and maintain/increase quality. Between 1979 and 1982, the British company spent £3 million on new equipment, the vast majority of which was not micro-electronically based. However, in 1979 they did buy one CNC milling machine for use in the Plane Department. This was for two reasons:-

i) A quality problem, which was bringing criticism from customers, had arisen on one particular range of wood planes. To prevent this required an additional milling operation which, the production engineers argued, could only be carried out on a CNC machine.

ii) A CNC machine, because of its higher productivity, would be capable of carrying out all the finish milling operations on the range of woodplanes involved and this would allow one person to perform the work previously carried out by six.

Therefore, for quality and economic reasons, the company bought its first CNC milling machine.

For similar reasons, a second CNC milling machine was bought in 1981.

The organisation of work around CNC

The first CNC had a female operator whose only task was to load and unload the machine. Everything else - programming, setting, inspection - was done by a programmer-setter.

This was decided upon by the Factory Manager for two reasons:-

i) It appeared the most economic method of operation: it allowed 6 setter-operators to be replaced by one operator and one programmer-setter. The latter was an existing setter, whose workload was re-organised to allow him time to programme and set the CNC as well as other machines.

ii) The Factory Manager wished to allay union fears that new technology would replace skilled shopfloor workers by showing that an existing setter could programme CNC.

Normally, the organisation of work around new machines would have been decided upon by a production engineer, a work study engineer and the supervisor of the section where the new machine would be located. The Factory Manager took on the task in this instance partly because he felt that the introduction of new technology could lead to industrial relations problems if not handled properly, and partly because he disagreed with the proposals of the supervisors and production engineers, who wished to see the latter do the programming. However, as recognition of this, he put a production engineer in overall charge of programming, but in practice he was never consulted by the programmer-setter.

The organisation of work for the second CNC was decided upon by a production engineer, work study engineer and supervisor, who on this occasion got their way. A production engineer was made responsible for all programming-related functions and a setter-operator carried out the other tasks.

As will be explained below, this was because the supervisory and production engineering staff, and the Factory Manager, had become increasingly worried about the control that the programmer-setter exercised over the first CNC.

The problems with the CNCs

CNC1: In terms of reliability, output and quality, the first CNC performed very well. However, there were problems relating to the operator's and programmer-setter's jobs:-

i) The operator found her job exceedingly boring and monotonous. All she did was load and unload the machine all day; the machine cycle, which was one minute, was fixed and in loading and unloading she was paced by the machine.

ii) With the machine cycle being fixed, the operator found it very difficult to earn bonus. This was exacerbated by the fact that operators and setter-operators on other machines, who did earn a relatively high bonus, could vary the pace of their work to allow them to take longer tea breaks or to finish earlier, whereas she could not.

iii) The supervisors in the Plane Department felt that they had lost control over the programmer-setter. This was because, despite the fact that one of the supervisors had received CNC training, no one else on the shopfloor was conversant with CNC programming and setting, and, therefore, did not know if the programmer-setter should take four hours or four days to set up the CNC. This was further compounded by the fact that he was shop steward for the Plane Department, and after he became programmer-setter, he negotiated a wage increase for himself.

iv) The production engineers continued to object to shopfloor programming; partly because, as one commented: "it's bad practice to let shopfloor workers decide upon production methods and speeds", but mainly because "it's job erosion letting a setter do our [production engineers'] job".

CNC2: The worries over the control that the programmer-setter had of CNC1 persuaded the Factory Manager that a different system should be adopted for the second CNC. This time, as mentioned, a production engineer actually performed all the programming functions. This pleased the production engineers, because they felt that the threat to their status had been halted. It also pleased the supervisors, who felt that with CNC2 they, and not a setter, would control the machine and its setter-operator; though in practice it was the production engineer who programmed the CNC who was in charge rather than the supervisors.

However, there were a number of problems with CNC2:-

i) The machine proved to be unreliable and kept breaking down. Ironically, when this happened, work had to be transferred from CNC2 to CNC1, which, because CNC1 used a different programming language, meant that the CNC1 programmer-setter had to write a new program. This would not have happened if CNC2 had been the same make of CNC as CNC1, but a different machine was bought partly because it was felt that it would thereby be easier to convince the unions that a different form of organisation was applicable.

ii) The problems of boredom and bonus which afflicted the operator on CNC1 also affected the setter-operator on CNC2.

iii) If a problem arose with CNC2, as happened once or twice a week, the production engineer had to be called. However, he was not always able to come immediately; indeed, his duties sometimes took him out of the factory altogether. Therefore, the machine could be standing idle for some hours until he was available. This did not happen on CNC1, because the programmer-setter was paid to give priority to that machine and was always within shouting distance.

There was one final problem which affected both machines: this was that some production engineers, as well as an outside consultant who had been involved in the CNC introduction, questioned the suitability of using CNC to manufacture the type, and quantity, of components for which the company were using them.

The situation at the first set of visits

The first set of visits began in January 1983, and the situation was very much as described in the last two sections. However, there were attempts to improve bonus earnings on the two machines. This was done in two ways:-

i) The Engineering Manager, who was also responsible for work study, had altered the bonus system for the CNC machines to allow the operators to earn more bonus for producing the same amount of work.

ii) The programmer-setter on CNC1 "fiddled" setting times to allow the operator to produce work, and so earn bonus, when the machine was officially classed as not operating. The setter-operator on CNC2 also used a similar arrangement to increase his bonus.

Both these arrangements, especially the latter, were against company rules, but everyone - including the Factory Manager - appeared to know of and condone them.

There were also attempts to alleviate the monotony of the operator's job on CNC1 by training someone else to alternate with her on the machine. However, the first person who was trained refused to go back on the machine after trying it for a week, because of the problems of boredom and bonus.

The other CNC problems still continued:-

i) The production engineers and the supervisors would have liked to remove the programming functions from the programmer-setter on CNC1, but did not attempt this because: "he'd kick up a fuss and the union would object to the job being downgraded".

ii) CNC2 still kept breaking down, and it appeared that this would continue to be the case, given the machine's general unreliability.

iii) CNC2 also continued to be idle on occasions because of the non-availability of the production engineer.

Despite the problems that arose, the Engineering Manager, who was responsible for initiating the purchase of new equipment, remained convinced that "CNC is the future for us if we're to remain in business".

These visits finished in April 1983, and the next set of visits were arranged for the following October.

The situation at the second set of visits

Since the first visits, the company's output had increased enormously owing to a number of product lines being transferred from America to Britain. This resulted, amongst other things, in the second set of visits being delayed until January 1984.

Since the first visits, there had been a number of changes which had affected the CNCs; these were:-

i) The new product lines were mainly woodplanes, and this increased the workload on the CNCs to the extent that they were put on two shifts.

ii) The original operator for CNC1 had left and two new operators were being trained.

iii) The supervisor responsible for CNC2 was promoted to production engineer; the programmer-setter was given his job and was no longer connected with CNC1. A new programmer-setter was being trained to take his place.

iv) The programmer for CNC2 was also made programmer for CNC1, with a view to these functions being removed from the new programmer-setter's job description. The latter would then be responsible for setting the CNC and sorting out problems as they arose.

v) A further CNC was being transferred from America to cope with the increased workload.

Despite these changes, there were continuing problems with the CNCs:-

i) The union was resisting attempts to downgrade the programmer-setter's job.

ii) The production engineer was so busy with the additional work generated by the transfer of products from America that he had to leave the programming of the new work on CNC1 to the new programmer-setter.

iii) The two-shift system on the CNC2 meant that for 8 out of the 16 hours that the machines were working per day, neither the production engineer nor the programmer-setter were available if a problem were to arise.

Therefore, the company still had two different methods of organising work around the two CNCs, and there was an increased number of occasions when both machines were idle because no-one was there to sort out programming-related problems.

A return visit was arranged to coincide with the arrival of the American CNC.

<u>The situation at the third set of visits</u>

The third set of visits began in September 1984, shortly after the arrival of the third CNC. The machine was not in production and, because of the workload of the Engineering Department, was not likely to be for some months.

However, there was a recognition that, with 3 CNCs, a more unified system of organisation was necessary. This was to be achieved, according to a production engineer, by:-

i) Making the production engineer, who was currently responsible for programming CNC1 and 2, responsible for all CNCs.

ii) Training other production engineers to programme in order to assist him and to provide cover in his absence.

iii) Putting all three CNCs under the supervision of the person who had been the original programmer-setter on CNC1. This meant that the machines would be supervised by someone who was familiar with CNC and could sort out programming problems if necessary.

iv) Training all the setters to sort out CNC problems, especially on the afternoon shift when the production engineers were not there.

v) Putting a setter-operator on CNC3, like CNC2, though CNC1 was to continue with only an operator.

It was felt that, over time, this would provide an adequate and efficient CNC organisation. Nevertheless, there were still obstacles in the way of this:-

i) The ex-programmer-setter for CNC1 was reluctant to become involved in sorting out programming problems, because he had been annoyed by the way that the production engineers had tried to take over programming. As he commented:- "They [the production engineers] wanted to programme, let them sort out the problems".

ii) The new programmer-setter, and the union, still maintained that he was responsible for programming CNC1 and not the production engineers.

iii) If other setters were to be trained to sort out CNC problems, they would have to be paid extra money for these new duties. The union might also claim that they should be trained to programme as well.

iv) There was the possibility that the setter-operator on CNC2 would object to other setters being given responsibility for his machine, on the grounds that it would downgrade his status. This was not, however, the case if production engineers were to be responsible.

In addition to the above problems, the issues of boredom and bonus still remained for the CNC operators and setter-operators.

Conclusion

A number of points arise from this case study. The first is that after 5 years, the company had still not achieved a stable form of CNC organisation. The reason for this appeared to stem from the opposition of the Engineering Department and the Plane Department supervisors to the organisation originally chosen for CNC. Instead, they wished to see a system more favourable to their own interests. Normally, this sort of problem would not occur because these two groups would determine how new machinery would be used. However, in this instance, the Factory Manager chose the organisation of work but, whilst it had advantages, when the second CNC was introduced, the production engineers and supervisors convinced him that their way was better in terms of control of shopfloor personnel, and a new form of organisation was decided upon for the second CNC. Nevertheless, the organisation of work around CNC1 proved difficult to change, despite attempts by production engineers and supervisors to move it more into line with CNC2.

The second point to note is the disparity between the formal and actual organisation of work. On CNC1, formally a supervisor and a production engineer oversaw the work; in practice, the programmer-setter was in charge. On CNC2, a supervisor and a production engineer were formally in control, but in practice it was the production engineer, and not the supervisor, who was in charge.

There was also a disparity between what should in theory happen and what actually happened with regard to bonus. All involved appeared to help bend the rules so that those operating CNC could earn more bonus than would otherwise be the case.

The third point to note relates to the performance of the CNCs in technical, economic and human terms.

In technical terms, the first CNC appeared to function perfectly well, whilst the second CNC appeared to be plagued with mechanical and electrical faults.

In economic terms, there appeared to be few problems with CNC1, but once again CNC2, because of its technical unreliability and the unavailability, on occasions, of the production engineer, left something to be desired. However, with regard to both machines, there was also the general question of whether CNC was the best technology to manufacture the products required economically.

In human terms, CNC1 had provided a very good job for the programmer-setter, whose work was more skilled and varied, and better rewarded, than that of other setters. The same cannot be said for the operator's job, which was both boring and monotonous. On CNC2, the situation was similar. The production engineer found that his programming-related functions added variety to his job and enhanced his status; whilst the setter-operator's job, which involved very little setting, was equally boring and monotonous to the operator's job on CNC1.

The supervisory staff, owing to their general lack of understanding of CNC, appeared to have less control over CNCs than over other machines, which obviously diminished their role.

Finally, there was obviously an awareness of all these problems, and the company was gradually trying to solve some of them; however, at the time of the last visit, there were still question marks over how successful they would be.

CASE STUDY NINE

The Company

This is a large company which was established in 1913 and was still controlled by the founding family until its take-over by a Swedish multi-national corporation in 1975. It is the leading European manufacturer of cutting tools such as drills and reamers. Its operations are located in four factories, the biggest of which, employing 1,100 people, is in Sheffield. The other three, employing 400 people between them, are located in Nottingham, Birmingham and Worksop.

The company had employed 2,400 people in 1975, but this had fallen, especially since 1979, to its present level of 1,500, due mainly to the shrinking of its market by one-third. Despite this, the company continued to be profitable, but at a much reduced rate. The Swedish parent company had gradually increased its control over the company and, since 1979, it had completely replaced the former top management. The Sheffield factory, which was the one being studied, was the headquarters for the other three factories and was also the largest production unit.

The factory is located on two sides of a road, in old multi-storeyed buildings. For these reasons, its manufacturing operations are split into a multitude of small departments. The CNCs were introduced into the drill turning section, which used to employ 44 people, but this had been reduced to 15 by the time of the first visit. The section had one supervisor who was responsible to the departmental foreman, who in turn reported to the Works Manager. The production departments were supported by a number of separate technical departments, such as Engineering, esponsible for the introduction of new equipment; Production lethods, responsible for the introduction of new products; and Work Study, responsible for job evaluation and bonus.

The Sheffield factory introduced four CNC turning lathes during the period covered by the study. The first two were installed in March 1983 at a cost of £141,000, the third was transferred from the Worksop factory in September 1983, and the last, costing £90,000, was installed in November 1984.

They were used to turn very simple products such as drill blanks, in batches ranging from 50 to 1,000, though the standard batch size was approximately 400. Machining times per product ranged from 30 seconds to 2 minutes, although occasionally this could be up to 5 minutes. Setting-up times for the machines ranged from 15 minutes to 1½ hours, and new programs took 30 to 40 minutes to write. Each CNC had some 10 to 15 different programs, each of which covered 30 to 40 different sizes of the same product.

The first visit to the company was made in January 1983, two months before the first CNCs were installed, and the last visit was made in February 1985. Initial contact was made with the Engineering Manager, whose department was responsible for urchasing and installing the CNCs.

Management-worker relations appeared to have worsened in the past 5 or 6 years, which was said to be partly due to the loss of jobs and partly due to the change of top management. However, the unions were very active on a range of management-union committees, but were criticised, by their own members, for lack of communication. They did attempt, with the introduction of the first CNCs, to negotiate a New Technology Agreement which would have guaranteed shopfloor involvement in programming and redeployment of displaced workers. However, management rejected the concept of such an agreement, and from that point, the unions appeared to have lost interest in the issue.

The situation at the first set of visits

The first visits to the company took place in January 1983, and therefore what follows is a description of the organisation of ork and plans for CNC before the machines were installed.

The organisation of work on the Drill Turning Section

There were approximately 40 machines on the section, most of which were either automatic or semi-automatic. A number of the achines had either been purpose-built, or specially adapted, or drill production by the company itself at its Worksop factory. Most of the machines, with one or two exceptions, were each used to perform simple turning operations on a narrow range of drills. There were three basic machine-related jobs on the section: setting; setting and operating; and purely operating. All three jobs were classed as semi-skilled and graded, like all machine-related jobs in the factory, on a scale of 1, least skilled, to 11, the most skilled. The setters and setter-operators were, in the main, on Grade 7, whilst the operators were on Grade 5.

The exact grade was determined by the Work Study Department, who carried out an evaluation of each job, and who also wrote a detailed job description.

Jobs in the factory were designed, as one engineer put it, on the principle of "minimum job content", in order to keep wages down and to reduce training time to a minimum. The supervisor on the Drill Turning Section commented that:

> Things are organised here so that a milkman, say, could drive in, get off his float, and, within a few weeks, be setting and operating a machine as well as the next bloke.

It was company policy for all shopfloor workers, where practical, to be on a bonus system, and this was extended to the CNCs when they were introduced.

The reasons for the introduction of CNC

The parent company, as a response to the recession, had instigated a programme to modernise and re-organise production in the four English factories in order to cut costs and increase quality. The turning section was seen as being particularly inefficient, mainly because most of the machines were old, inaccurate and limited in the type of operations they could perform. The specific reasons for the decision to buy the first two CNCs were:-

i) The two CNCs would replace 10 existing machines.

ii) One person would operate both machines at once, because each CNC was loaded and unloaded by a robot.

iii) The machines the CNCs replaced were so inaccurate that after the drill blanks were turned, they had to be ground to size before going on to the next operation. The CNCs would eliminate the need for grinding.

iv) The number of people involved in turning and grinding would be reduced.

Therefore, in order to increase quality and reduce costs, the company decided to buy two CNCs with two robots. However, it was not clear whether or not alternatives to CNC had been considered, but it was clear that the Engineering Manager saw his department's involvement with new technology as a way of enhancing its status within the company.

<u>The proposed organisation of work around CNC</u>

It was the Engineering Manager's intention that two of his staff, one from Sheffield and one, who had previous CNC experience, from Worksop, would spend several months with the machines in order to write and prove tapes and sort out any teething troubles. The machines were then to be handed over to the production staff and would be operated, on two shifts, by two setter-operators. Their job would be to set up the CNCs and position the robots and, when the machines were in operation, to monitor them. It was not envisaged that they would need any programming knowledge because all they would have to do would be to feed in a master program, which they would then amend, using a written edit sheet provided by the engineers, to produce the required size of drill. In addition, the machines had a mechanism for automatically checking and adjusting the size of the drills being produced, to ensure that they were within the permitted tolerances. The section supervisor, like the setter-operators, was to be involved from the start, but he was not expected to be involved in sorting out either setting or programming problems.

This organisation was chosen for three reasons:-

i) It allowed increased managerial control over the pace and quality of production.

ii) It kept the input of the setter-operators to a minimum, and thus kept their wages down.

iii) It ensured that the Engineering Department would keep control of the programming of the CNCs.

The situation at the second set of visits

The second set of visits commenced in March 1983 with the arrival of the CNCs. The two engineers believed it would take them three to four months to prepare the machines for full production; the majority of this time was to be devoted to writing and proving the programs for the CNCs.

The engineers, along with the supervisor, who was eager to learn as much as he could about the CNCs, had already completed a one-week programming course, and one of the supplier's installation engineers was to spend two or three months helping them to bring the CNCs into production. The two setter-operators were also to be present during the installation period, in order to receive training for the machines.

At this time, the introduction appeared to be going as planned, though there were some potential problems:-

i) The engineers were worried that even after all the programs had been proved, minor programming problems might still arise. In order to deal with this eventuality, the supervisor, mainly at his own insistence, was to be trained to deal with these.

ii) The CNCs, whilst being located in the turning section, were put in a separate enclosure to prevent anyone tampering with them or the robots. The engineers were concerned that lack of contact with other workers, coupled with long periods of machine-minding, might lead to boredom and lack of motivation for the setter-operators.

iii) There was also the worry, given the fixed production rate of the CNCs, that it would be difficult for the setter-operators to earn the same level of bonus as other workers.

Nevertheless, these were seen as minor problems which would eventually be resolved.

The situation at the third set of visits

The next set of visits began in August 1983, when it had been expected that the CNCs would be in full production. However, the introduction process had proved more complicated than had been envisaged, and was now not expected to be completed before October. Nevertheless, the Engineering Manager expressed himself pleased with the progress that had been made. The outstanding problems were as follows:-

i) There was a general acceptance that there would be a greater need for setter-operator intervention than had originally been intended. This was partly due to problems with the automatic sizing mechanism, partly due to the fact that there would need to be the occasional new program for the machines, but mainly because, as the supervisor commented:

> We had a simplistic view of CNC: we thought all you did was put the tape in, press a few buttons, and away you go. It's not like that at all.

ii) The engineers and the supervisor had spent so much time on the machines that the setter-operators had been pushed into the background and had received less training than was originally intended.

iii) The CNCs were to be worked on two shifts: 6 am to 2 pm and 2 pm to 10 pm. However, the supervisor and the engineers only worked from 8 am to 4.30 pm, and it was not clear what would happen if a problem occurred, which the setter-operators could not deal with, outside these hours.

iv) The setter-operators resented being kept in the background, and saw this as an indication that the management did not want them to learn about programming, because the company might then have to pay them more money. They saw this as being confirmed by the fact that they were not to be allowed to take time off to attend an evening programming course, which would have required them to miss part of an afternoon shift, at a local college.

v) The setter-operators felt that the majority of their time on the CNCs would be spent monitoring the machines for faults, but that when something did go wrong, they would not be able to deal with it. Therefore, they saw their job as both boring and frustrating.

It was not, at this time, clear how important these problems would be once the CNCs were in full production, or how they would be resolved. However, the issue of isolation which had appeared to be a problem did not materialise, because other workers came into the CNC compound to talk to the setter-operators with no hindrance.

One final development should be mentioned. There was a CNC operating at the Worksop factory. This had been bought in 1979 originally to produce small batches of complex machine parts, but machine building at Worksop had declined and it then became used to produce large batches of reamers. However, reamer production was to be transferred to Sheffield, and the CNC was also to be transferred. The machine was to be located on the drill section because the supervisor had, successfully, argued that it made sense to put all CNC lathes on one section under one person. The setter-operator for the machine, which was hand-loaded, was also to be transferred, though it was not clear what his duties would be. At Worksop, he had been trained, by the engineer who was helping to introduce CNC into Sheffield, to programme as well as to set and operate. This was because:-

i) The original products were complex, varied, and in small batches. This meant that complex programs and set-ups were frequently required.

ii) Worksop was a small factory, employing 70 people, and the CNC engineer was not always available to write and prove programs. It therefore made sense to train the setter-operator to perform these tasks. In practice, he and the engineer shared the programming role.

However, this system did not appear to fit in with the practice that was developing in the Sheffield factory. Therefore, it remained to be seen what the setter-operator's role would be once this new CNC was in operation.

The situation at the fourth set of visits

The fourth set of visits began in February 1984. By this time, the first two CNCs had been in full production on two shifts for three months, and a third setter-operator was being trained with a view to the machines being worked on three shifts. Despite the fact that the machines were in production, the company's Sheffield-based engineer was still making regular visits to the machines because of continuing problems with the sizing mechanism and with the robots. However, the main problems that had arisen were related to the setter-operators. These were:-

i) The setter-operators had been led to believe that they would be regraded to Grade 9 or 10. However, their jobs had been assessed by the work study engineers and they had been put on Grade 8. Not unnaturally, they were upset by this, and it had a severe effect upon their performance. Indeed, such was the change that the supervisor, who sympathised with them and had told them to appeal against their grading, had disciplined them for lack of co-operation.

ii) It was apparent that the setter-operators' training in relation to programming had been insufficient, and that this was causing delays and in some cases costly accidents. However, they were no longer prepared to learn to deal with these problems; as one of them said, "I'm gradually losing interest, there's no incentive for us". Therefore, the supervisor, who along with the engineers was writing new programs, was dealing with programming problems, even to the extent that if something went wrong on the evening shift, he would be rung at home; though on occasions this merely resulted in the machine being turned off until the next day.

iii) The quality of work from the machines was lower than expected. This was partly because the setter-operators, especially between 4 pm and 10 pm on the afternoon shift when the supervisor was not present, increased speeds in order to produce more work and earn more bonus. However, as speeds increased, quality decreased.

iv) These problems were exacerbated by the supervisor and the engineers believing that any new or modified programs they produced were correct and did not need proving. Therefore, when problems did occur, the tendency was to blame the setter-operators, even though in some instances the fault lay with the program.

t was not clear how these problems would be resolved, though there was a tendency for managers to ignore them or blame someone lse. The Engineering Manager commented that he had tried to ake his counterparts in Production understand the problems, but hat:-

> . . . there's a terrible tendency amongst management in production to think that they don't need to have operators with any real skill; that all you need to do is push the buttons and the machine will take care of everything else.

The Works Manager for his part denied that there were any significant problems, but pointed out that:-

> If there are problems with the training, that's not my department; it's Engineering who are responsible for that . . .

There were also problems with the CNC that had been transferred from Worksop. The job of the setter-operator, who was continuing, in co-operation with the supervisor, to do some programming, had also been assessed by Work Study. He was put on Grade 9, but this was less than he was earning at Worksop, and, therefore, he was not pleased with the situation. However, he had not yet been put onto bonus; in the interim he was being paid a fixed bonus. The quality of his work and the level of co-operation, though not the output, was greater than with the other two CNCs.

One further development was that the company had decided to buy another CNC, which was due to be installed in June 1984.

The situation at the fifth set of visits

These commenced in December 1984, which was later than expected, owing to the late arrival of the fourth CNC.

The situation with the first two CNCs had not improved; indeed, it had probably deteriorated, given that both setter-operators were seeking new jobs. This was despite that fact that they had won their grading appeal and were now on Grade 9. Nevertheless, the quality of work from the machines had not improved; the setter-operators' work was now having to be inspected by someone else in an attempt to remedy this. They had also been warned that their bonus earnings were, to use the supervisor's phrase, "ridiculously high", and that all their work would be retimed if they did not earn less. Needless to say, this did not increase their level of co-operation.

They were, however, pleased by the fact that the idea of working three shifts had been abandoned and that they were working alternate day and night shifts. This meant not only that they received an increased shift allowance, but that every other week, when they were working nights, they were entirely free from supervision.

The situation with the third CNC had also deteriorated. The setter-operator had also appealed against his pay and had been regraded to Grade 10. However, he had been warned that his production rate was too low and that if it did not improve he would be put on an output bonus, rather than a fixed bonus. His output did not improve and, therefore, he was put on bonus. This resulted in an increase in output, a decrease in quality, and the setter-operator looking for another job.

With regard to the fourth CNC, which was installed in November, it was too early to tell whether or not the problems that had occurred on the other CNCs would occur with this machine. The setter-operator was the one who had been trained to operate the first two CNCs when it was planned that they would be working on three shifts. He had spent a week being trained by the installation engineer and felt that the training had been very good. The engineers for their part believed that he would have to be trained to a higher level than the setter-operators on the first two CNCs, especially as this CNC, and the products it was making, were more complex. However, the Worksop engineer felt that his Sheffield counterpart, who was in control of the introduction, did not fully appreciate this. On the other hand, the supervisor, who was spending more and more time dealing with CNC problems, believed that "the time might come when we have to have a specialist setter to trouble-shoot on the CNCs; someone who could act as a back-up to the setter-operators."

Therefore, it was not clear how CNC would develop, but the company were firmly committed to CNC and were expecting to introduce another CNC lathe in April 1985.

Conclusion

A number of points arise from this case study. The first is that the decision to buy CNC and the method of its introduction were the responsibility of the Engineering Department, especially its Manager. The manager and the Sheffield engineer, though perhaps not the one from Worksop, wished to see their own role bolstered and that of the setter-operators kept to a minimum. In the latter respect, this accorded with established views of shopfloor jobs within the company. Nevertheless, the experience of CNC convinced those involved that there was a greater need for setter-operator intervention than had originally been envisaged. However, their failure to take appropriate action, or to convince others such as the production management and the work study engineers quickly enough of this necessity, had resulted in many problems.

The second point to note relates to the disparity between the formal organisation of work and the actual organisation. Formally, the engineers wrote the programs, which were then handed over to the setter-operators, who dealt with them after that. However, in practice, the supervisor also wrote programs and, on CNC1 and

CNC2, he also became involved in sorting out any subsequent problems. On CNC3, the setter-operator also wrote programs, in conjunction with the supervisor. Therefore, the supervisor spent much of his time performing work which, in theory, should be carried out by the engineers and the setter-operators.

Thirdly, the performance of the CNCs is to be assessed in technical, economic and human terms.

In technical terms, there were some problems with both CNC1 and CNC2, the main one concerning the mechanism for measuring and adjusting the size of the parts being machined. The effect of this latter was to require greater setter-operator intervention.

In economic terms, the quality problems that arose on CNC1 and CNC2, and possibly also CNC3, obviously reduced the expected financial benefits. There was also the issue raised by one of the engineers of the suitability of CNC for the production of simple components in such quantities.

In human terms, what could have been good jobs for the setter-operators on CNC1 and CNC2 were marred by the failure to recognise early enough the need for them to have a wider role. This was compounded by the failure to evaluate and grade their jobs properly in the first instance. Taken together, these two mistakes acted to reduce their willingness to learn and co-operate, whilst increasing their pursuit of bonus payments. A similar result occurred with CNC3.

The role of the supervisor, on the other hand, was expanded, and his job status and satisfaction were increased by his contact with CNC. Whether he would be able to carry out his normal supervisory duties and cope with his CNC role as more and more CNCs were introduced remained to be seen.

With regard to the engineers, they certainly enjoyed their contact with CNC. They believed that it enhanced not only their individual status but also that of the Engineering Department as a whole.

In summary, there was obviously a potential for creating satisfying jobs and for achieving the company's production requirements. However, in the case of the setter-operators, it was the failure to achieve the former which led to the problems in achieving the latter.

P A R T   T H R E E

CHAPTER ELEVEN

UNDERSTANDING TECHNICAL CHANGE

INTRODUCTION

This, the concluding chapter in the Thesis, will compare the case studies presented in the last four chapters. It will show why the organisations adopted CNC, how they decided how to use it and what the impact was, especially in human terms. It will also examine what alternative methods of use were considered.

The conceptual framework presented in Chapter 4 will then be examined in the light of the case studies. In particular, the case studies will be used to demonstrate the relevance of the internal organisational factors to the change process. It will also be shown how those factors relate to and are influenced by the external factors.

The chapter will conclude by arguing that the research has supported the conceptual framework and by presenting guidelines for the introduction of new technology.

Nevertheless, it will be pointed out that the main stumbling block to the successful adoption of new technology is the continuing influence upon managers of the philosophy and precepts of Scientific Management.

THE CASE STUDIES

This section will compare the case studies with each other and in relation to the main issues under discussion, as described in Chapter 5, namely:-

1 Why do organisations adopt CNC?

2 How do they decide how to use it?

3 What is the outcome in terms of the organisation's technical and financial objectives, and in terms of work organisation and job design?

What alternative forms of use were considered/were available?

1 Why CNC?

Not surprisingly, all of the companies studied mentioned the need to increase productivity/competitiveness or to reduce costs/labour as reasons for buying or continuing to buy CNC. Four companies, cases 2, 4, 8 and 9, also adopted CNC because they wished to improve/maintain product quality; whilst three companies, cases 1, 3 and 4, saw CNC as reducing the present or future need for skilled labour or as a means of avoiding a future labour/skill shortage. Only in one instance, case 3, was CNC introduced specifically as a method of increasing the management's control over the production process.

These are all, perhaps with the exclusion of the last, reasonably obvious and understandable reasons for buying new technology. However, as well as these, one other reason was also given by seven companies, the exceptions being cases 6 and 8, which was that, in their opinion, new technology was "the future"; they believed that if their companies did not adopt CNC, they would eventually go out of business. What is surprising is that, although this emerged as a major reason for the purchase and continued usage of CNC, none of the companies appeared to have investigated or questioned this assumption. This is shown by an examination of the assessments, or lack of them, that the companies prepared in order to justify the purchase of CNC: out of the 9 companies, there was no instance of any alternative to CNC being seriously considered prior to purchase. Those in each company who were responsible for initiating the purchase of new equipment appeared to have decided that CNC was required and then to have justified it in terms of its superiority over existing equipment rather than in comparison to other alternatives. Indeed, in four companies, cases 1, 2, 3 and 5, no financial assessment appeared to have been carried out at all. The assessment carried out in three of the companies, cases 4, 8 and 9, can at best be described as brief, and only in two companies, cases 6 and 7, were extensive financial justifications put forward.

Therefore, the most surprising, and perhaps the most significant, reason why these companies bought CNC was an unquestioned belief that CNC, because it was new technology, was "the future", rather than any firm evidence that it was the best option available.

2 Factors which influenced the use of CNC

In examining the factors that influenced how CNC was used, it should be noted that, generally, only one person, usually the person responsible for initiating the purchase, decided upon the original organisation of work around CNC. The person may have consulted, or been influenced by, others but the initial decision was theirs alone. A variety of reasons were given to explain why a particular choice was made, but in practice three factors appear most influential:-

i) To accommodate CNC within the existing structure, practices and personnel of the organisation with the minimum disruption. (Cases 1, 4, 5, 6, 7, 8 and 9)

ii) To maintain or increase management control. (Cases 3, 5, 6, 7 and 9)

iii) A belief that CNC was relatively simple to use. (Cases 1, 2, 3, 7, 8 and 9)

Nevertheless, despite having decided upon a particular form of work organisation, once the CNCs had been introduced, problems arose which, in most cases, required changes to how the machines were used or what particular individuals did. This was for four reasons:-

i) Poor planning of the introduction process, especially lack of training for those involved, which in some cases almost amounted to incompetence. (Cases 1, 2, 3, 5 and 9)

ii) A realisation that CNC required greater skill/involvement from operators, setters and even programmers than had been envisaged. (Cases 2, 3, 5, 7 and 9)

iii) Opposition to, or lack of co-operation with, the original plans from individuals or groups within the organisation. (Cases 4, 5, 7, 8 and 9)

iv) A desire to increase management control over CNC. (Cases 3, 5, and 8)

Nor was it the case that these were "teething troubles" which gave way to a relatively stable and efficient form of work organisation. Indeed, in at least one of the companies, case 3, stability was never achieved, whilst in others changes either happened incrementally or took place after some years of stability. These were caused by:-

i) The acquisition of further CNCs. (Cases 1, 3, 5, 8 and 9)

ii) The departure of existing employees and/or the arrival of new employees. (Cases 1, 3, 6 and 9)

iii) The industrial relations climate/the relations between groups and individuals. (Cases 2, 3, 8 and 9)

Therefore, in the nine cases studied, it can be seen that a variety of factors were present which influenced the choices that were made or which brought about the need for change. This meant that in some companies a stable form of organisation was never achieved, or that changes took place after a number of years of stability, or that change occurred gradually over a period of years.

The decision process and the change process were influenced by elements such as the type of products, the existing structure of work, the need to accommodate additional CNC machines, etc. However, more powerful influences appeared to come from the individuals and groups involved, and revolved around such factors as values, attitudes, self-interest, power, and competence. These latter factors will be returned to in the section dealing with the conceptual framework, but it should be pointed out here that they were influential in making the decision-making and change processes less rational, less stable, and less efficient than might have been expected.

3 The outcome

In examining the consequences of technical change, there are three elements that need to be considered. These are the organisation's technical objectives; its economic objectives; and the human aspect of change in terms of the resultant work organisation and job design.

In technical terms, a significant proportion of the companies concerned experienced technical problems with the machines they bought and/or there were doubts about the appropriateness of CNC in their particular situation.

In the instance of case 1, the company found that their machining centre was prone to faults. Whether this could have been avoided if tests of the machine had taken place before its purchase is uncertain. However, common sense would indicate that such tests should in any case be carried out. Case 2 is another example where machinery failure occurred. The problem was caused by the products being too heavy for the machine, rather than any intrinsic fault in the machine itself. In this instance, it should have been possible to predict that this would happen before the machine was purchased.

In cases 4, 8 and 9, there were doubts about whether CNC was the most appropriate technology for these companies. In case 4, this was because the company were moving away from metal products to plastic ones; whilst in cases 8 and 9, given the simple nature, and large quantities, of their products, less sophisticated - and less costly - equipment than CNC might have been more appropriate. The company in case 8 also experienced reliability problems with one of the CNCs they bought.

In case 3, there was some doubt about whether *in programming* terms the number of different CNC systems and languages was counter-productive. However, the company in case 5 had a similar variety of systems but experienced none of the attendant programming problems. Therefore, in case 3, the problems xperienced may have been related more to the turnover, and ack of training, of programmers than the number of different systems.

Therefore, out of the 9 companies studied, 5 experienced either technical problems or doubts about the appropriateness of the technology. This would once again, as mentioned earlier, indicate that the companies may have benefitted by carrying out more rigorous assessments of their needs and the equipment available prior to the decision to purchase.

Given the number of companies who experienced technical problems, it is not surprising that a significant proportion also had economic problems with CNC. However, not all those who had technical problems also had economic ones with the CNC as such, and vice versa.

In case 1, the company's economic problems in the first few years revolved around their failure to train and retain staff; whilst later, with the second and fourth CNC, the problem was one of insufficient work; similar problems were experienced by the firm in case 2.

In case 3, the company's problems were not technical at all, but revolved around poor industrial relations and the attendant high labour turnover.

In the instance of case 5, the company experienced training and labour turnover problems in the first year of CNC. After that time, the situation was stable until 1984, when the company's attempt to re-organise the CNC section resulted in a decline in its efficiency.

In case 8, the company not only experienced technical problems with its second CNC, but it also experienced organisational ones which caused it to stand idle when it could have been producing.

In case 9, apart from the general question of the appropriateness of CNC, there were problems with training and the roles of the setter-operators, which led to quality and output difficulties.

Therefore, as can be seen, technical and/or organisational problems brought about economic problems for a number of the companies. The issue is not whether companies benefitted financially from CNC as such, but whether, in the absence of technical or organisational problems, some could have benefitted more. The answer has to be that a better financial return on their investment could have been achieved in a number of cases.

In human terms, as in technical and economic ones, the outcome was mixed; some of the jobs created were good, some bad, and some indifferent. In Chapter 6, it was argued that in Job Design terms, the best form of work organisation would be where one person was involved in programming, setting and operating; and that the worst would be if these jobs were fragmented, leaving a few people, such as programmers, with good jobs and the majority, such as operators, with bad ones. In practice, this proved to be the case: in case 1, the programmer, who also occasionally set and operated the CNCs, had a very good job; whilst the operator in case 8 had a very bad job. This is not to say that those solely involved in programming did not have satisfying jobs - most obviously did - but that the price of their good jobs was that others, such as operators, were solely involved in the less skilled and more monotonous aspects of CNC.

However, it was not job content alone that brought, or reduced, job satisfaction. Other elements, such as pay and bonus, status, industrial relations, and personal relations, also played a role in increasing or decreasing job satisfaction. How these factors interrelate with job content can be seen by a brief examination of each case study.

In case 1, much of the early difficulty in training and retaining staff was caused by the attitude and expectations of the Technical Director; labour turnover decreased and satisfaction increased as his CNC involvement decreased.

In case 2, the dissatisfaction of the setter-operators related to job content, the decline in their programming role, and to the bonus system.

The problems of the company in case 3 appeared not to be related to job content at all; the flexibility and involvement in programming of the setter-operators should have led to job satisfaction. Instead, the poor industrial relations climate, caused in the main by the attitude of the Managing Director, led to dissatisfaction and high labour turnover.

In case 4, the machine-minders complained of boredom, but it appeared that it was the setters who were most dissatisfied, due partly to a perceived loss of autonomy and partly to personal friction between them and the programmer.

The setter-operators in case 5 moved from a position where they were relatively satisfied with their jobs to one where they were dissatisfied. This was caused by a re-organisation of their jobs which increased the skilled component of their work and decreased the more boring elements. It might have been expected that this would increase their satisfaction, but it had the reverse effect; this was partly because the change was imposed on them without consultation, and partly because there was insufficient time to provide the necessary additional training.

In case 6, it was the arrival of a new programmer who wished to discard the setting aspects of his job that led to the upgrading of the CNC operators' jobs. A similar wish by the programmer in case 7 led to the CNC in that company being worked by setter-operators rather than operators. In both cases, this change appears to have created the conditions for increased job satisfaction.

In case 8, the dissatisfaction of the operator and the setter-operator caused by the monotony of their jobs was exacerbated by the bonus system that was in operation.

In case 9, the conditions emerged for the various setter-operators to take on programming and proving functions which should have given them interesting jobs. However, the pay and bonus system, together with the attitudes of the engineers involved, proved counter-productive in terms of satisfaction and motivation.

Therefore, as mentioned earlier, the jobs that were created were of mixed quality, owing not only to the content of the jobs but also to other factors as well.

Two other developments should also be mentioned. The first is that in some companies, the supervisory staff either received no training, or very little training, for CNC. This resulted in some instances, such as case 1, where supervisory staff had very little involvement with CNC and other people such as programmers, informally, took on their supervisory role. Indeed, in case 8, the supervisors felt so threatened by this situation that they actively sought to have the work organisation around CNC changed in order to have a production engineer put in charge of CNC rather than a setter. This did not alter their own position, but it did mean that control rested with office rather than shopfloor personnel.

This leads into the second development to be noted, which is the tendency for programming, and thus decisions regarding methods and speeds and feeds, to be carried out by office rather than shopfloor personnel. As noted in chapters 2 and 6, there has been a long-run tendency, stretching back to the 19th century, towards reducing the decision-making scope of machine operators. However, the prime method of achieving this in the past, the separation of setting from operating functions, did at least leave skill and decision-making with shopfloor staff. Now, with CNC, these decision functions and skills are moving from the shopfloor and into the office, or, as Howick (1965) - previously quoted in Chapter 6 - put it:-

> The important decisions that affect unit cost, delivery dates, and product quality are, with N/C, in the hands of managers and professional employees, not the operator. (p 105)

Howick exaggerates this picture somewhat: quality, output, etc., can still be influenced considerably by shopfloor workers; and the interests of "managers and professional employees" cannot be completely linked. Nevertheless, the tendency towards the removal of shopfloor decision-making does exist and, in most of the cases examined, appeared to grow over time. The result of this is not only that important skills are denied to shopfloor workers, but also that their ability to control their work - an important component in good job design - is much reduced, both of which can have an adverse effect on performance.

The alternatives

One very noticeable feature of the case studies is that, willingly or unwillingly, all the companies either considered or experimented with alternative methods of work organisation. These ranged from situations where one person programmed, set and operated a CNC, to others where these functions were split amongst three different groups. In some companies, such as case 4, this amounted to no more than a brief, early, attempt to rotate CNC operators. In other companies, such as cases 1 and 3, a variety of arrangements from programmer-operators to separate programming, setting and operating personnel were tried, and existed side by side, over a number of years. Yet again, in cases 5 and 6, a form of work organisation which had existed for some years was changed in important respects. In the former case, the company moved from setter-operators towards setters and operators; in the latter, the reverse took place.

Four significant points emerge from the way in which alternatives were considered or tried:-

i) Whilst in some cases the changes were willingly initiated and consciously planned by the companies' managers, in other cases, the majority, they were initiated by, or informally organised between, those technical, supervisory or production staff involved with CNC.

ii) Economic and technical considerations were not always the main reason why changes were made, nor was it the case that the alternatives tried always resulted in improved performance from the CNCs. Indeed, it is not too much to say that issues such as management control, the wish to improve individual/group status, and the need to fit in with existing structures and practices proved of more importance in practice than economic or technical considerations.

iii) The divisions between programming, setting and operating functions are not clear-cut and they can, and do, shift over time as circumstances change. Given this, the attempts made by some of the companies to make clear-cut divisions between these functions were neither practicable nor productive. Rather it would appear to make more sense, if tasks are to be divided, that those involved in one function have an appreciation of the other functions.

iv) Despite the deeply-held belief by personnel in some of the companies that an output-related bonus system was the most efficient and productive method of motivating workers, it should be noted that, as far as CNC is concerned, it appears to be counter-productive. Not only were there practical problems for those companies which tried to apply an existing bonus system to CNC (in some cases they had no choice but to bend the rules), but also it appeared to have a detrimental impact upon quality and motivation. Neither was it the case that those companies which did not operate a bonus system had output problems. It would appear, therefore, that in the case of CNC, a bonus system creates more problems than it cures.

Therefore, in considering what alternative forms of work organisation and job design are feasible with CNC, it would appear that practical and economic factors do not appear to prevent Job Design criteria being applied; however, as shown, many other factors do.

HE CONCEPTUAL FRAMEWORK

In Chapter 4, a conceptual framework was presented which saw four groups of factors affecting the introduction and use of new technology. These were general and specific external factors and general and specific internal factors. These will now be examined in the light of the nine case studies. However, as mentioned earlier, the case studies were concerned with internal rather than external factors. These will therefore be considered firstly and in more detail than the external factors.

Internal general factors

The internal general factors which were put forward as influential are as follows:-

Management-worker relations: There was no example in the nine case studies where this factor, at an organisation-wide level, appeared to influence the introduction of CNC. However, in case 3, where the organisation and the sub-unit were virtually the same, poor management-worker relations brought about a need for a variety of ad hoc arrangements to cope with the problems that emerged, especially the high labour turnover. However, in general, management-worker relations at the organisation level appeared to have little impact upon the introduction and use of CNC, though this may be related to the lack of bargaining power faced by the workers in these companies, which in turn was the result of the high levels of redundancies and the precarious market position experienced by the companies. If this is the case, then an economic upturn and a growth in employment might make this a more important factor than it appears at the moment.

Profits and performance/goals and strategy: These two sets of factors could not, at least in the cases studied, be separated because it was the organisations' financial position which predisposed them to change their production techniques in order to achieve the goal of cutting costs and/or improving output. CNC was seen as the method or strategy which would achieve this in the particular areas concerned. In the two large companies, the goal of cost-cutting/performance improvement was accompanied by detailed plans and finance to re-organise and modernise production methods. However, in the medium-sized and smaller companies, with the exception of case 3, the arrangements and plans were more ad hoc. Indeed, in all sizes of companies, there was a tendency to seek one-off, short-term, solutions to implementation problems rather than consistently pursuing a general strategy. This lack of consistency and deliberate planning was also seen in the selection of the particular technology, in that CNC appeared to be chosen because it was a "New Technology" rather than because of any concrete evidence that it was the most appropriate technology.

It was also the case that, in the large and medium-sized companies, those managers who set the general goals were different from those who developed and implemented the particular strategy of introducing CNC.

Therefore, whilst in all these cases a definite link can be seen between profits and performance, and goals, the link between goals and effective strategies is less clear, and the strategies themselves were often based on incorrect, or unsubstantiated, assumptions, and were carried out in an ad hoc and inconsistent manner.

Existing technology and products: There is no evidence in the case studies that the existing technology acted as a constraint on how CNC was used, although it obviously influenced the decision to buy this particular type of new technology in the first place. However, the type of product being manufactured is a different matter. It can be seen, in the two large companies which manufactured simple products in large batches, that there was a predisposition amongst engineers and supervisory staff to reduce the skill involved in shopfloor jobs. In the two small companies, especially case 1 where small batches were manufactured, an opposite tendency can be discerned. In practice, looking at all the cases, it can be seen that where the more complex products were being manufactured, there was a greater need for operator/ setter-operator skill and intervention than in the instances where simple components were being made. Nevertheless, in all instances it appeared that product complexity, whilst being a constraint, was neither the only nor the most decisive factor in influencing job design and work organisation around CNC.

Size and structure: The relationship between these two factors was as expected: that is that increasing size was accompanied by increasing fragmentation, formalisation and specialisation. This was especially the case with regard to supervisory, management and support functions. In case 3, these functions were carried out basically by two people, but in case 5 they were carried out by two different departments working closely together, and in case 9, by numerous departments which had difficulty communicating and co-operating.

With regard to shopfloor jobs, the degree of fragmentation was less pronounced; that is to say, there was not a great deal of difference between the level of fragmentation between, say, case 4 and case 9. However, the level of formalisation and specialisation was greater in terms of such features as job evaluation procedures; written and rigid job descriptions; and written rules and practices covering the organisation and recording of work. This in turn meant that it was more difficult to change the organisation of production in the larger companies, once a system had been adopted, and the flexibility that existed in the smaller companies for experimenting with and modifying work arrangements was reduced.

Philosophy/culture: As stated in Chapter 4, it was envisaged that these would work to produce a set of organisational norms and values which would influence how those in the organisation would behave or were expected to behave, especially, in this instance, with regard to change.

Whilst it was never envisaged that a rigorous examination of each organisation's philosophy/culture could be undertaken, it was possible, by examining the practices and values, especially of managers, to gain valuable insight into this. In the larger, and even in the small and medium-sized companies, an emphasis on control, a belief in monetary motivation, and, as expressed in case 9, a tendency towards "minimum job content" could be clearly seen. Not surprisingly, these tended to be more formalised and difficult to alter in the larger companies, whilst in the medium-sized and smaller ones they tended to emerge more in the attitudes and values of the managers and could, as in cases 6 and 7, be more easily overcome.

Nevertheless, it can be seen that the underlying philosophy of Scientific Management was actively present and influenced the use of CNC in all the companies, with the possible exception of case 1, but that its more formal and structured elements only emerged, as might be expected, as company size increased.

The history and development of the organisations: As with the above, it was not envisaged that a thorough examination of these factors could be made. However, a study of the nine companies' recent history and development shows the importance of these factors.

Perhaps the most important development in all the companies was the decline in their financial position. Not only did this cause them to seek ways of cutting costs/increasing performance, but the attendant redundancies also reduced the ability of their workforces to resist/influence the change process. However, other developments also impacted upon the companies and the way they operated. In case 9, the change of ownership and top management was, partly, responsible for plans to re-organise production. In case 8, the parent company's increased control led to a redistribution of work which brought the third CNC to the company. Minor changes such as the appointment of the new programmer in case 6 and the Managing Director's take-over of responsibility for day-to-day production in case 3 also had a significant impact.

Therefore, as can be seen, an understanding of an organisation's history and development is a necessary prerequisite to understanding the organisation itself.

Internal specific factors

The internal specific factors which were put forward as influential are as follows:-

The size and nature of the proposed change: The companies all began by introducing one or two CNCs, which meant that the rest of the sub-unit, other than those most closely affected, initially remained relatively unchanged. However, as time went on, and particularly in the cases where more CNCs were introduced, the impact on the rest of the sub-unit grew and problems of integration and change emerged. These problems ranged from the role of supervisors, such as in cases 1 and 8, to problems of transferring work from existing machines, as in cases 2 and 4. In some instances, problems of integration and organisation continued unresolved for some years, as in cases 1, 3 and 8, whilst in other instances, cases 4, 5 and 6 for example, stability was established relatively quickly, though not without some initial problems. However, in the instance of cases 5 and 6, further changes, which met resistance, did take place after some years of stability. Therefore, whilst small-scale change may initially have little impact on the sub-unit as a whole, this is unlikely to remain so over time, especially when additional machines are introduced.

Sub-unit performance and importance: In all the cases, the sub-unit was seen as being important, especially in the smaller companies, where in some cases it constituted virtually the entire organisation. It was also the case that CNC was introduced, in all the companies, to improve the performance of the sub-unit.

Not surprisingly, therefore, the tendency was for senior managers to involve themselves in the selection and introduction of the technology, whereas in other instances they might not have done so.

Sub-unit structure: There was a tendency when first introducing CNC, particularly noticeable in the large and medium-sized organisations, to use the existing formal structure as the model for CNC. However, in a number of instances, the replication of the formal structure ignored the actual basis on which work was organised.

Two specific examples of this are the role of supervisors and the issue of bonus. With regard to the supervisors, in cases 1 and 8 there appears to have been a tacit assumption that their authority stemmed from their formal position, and the importance of their knowledge of the technology was ignored. This led to an undermining of their role and authority, which was transferred, unofficially, to others. The issue of bonus follows similar lines, the assumption being, in some cases, that a bonus system suitable for existing machines would be suitable for CNC. This was not the case, because on conventional machines operators could "fiddle" the system with no detriment to quality, whilst on CNC, the fixed cycle times prevented this.

Therefore, whilst companies wished to replicate the existing structure of work, the failure to recognise the important elements on which the formal organisation of work was based caused a number of the problems that have been described in the case studies.

Management-worker relations: As mentioned in the section on general factors, management-worker relations across the organisation did not affect the introduction and use of CNC to any great extent. However, the situation was different in the particular sub-units, where in nearly all cases problems arose. In case 1, there were problems between the Technical Director and the various setter-operators which had a detrimental effect on the efficiency and organisation of CNC for some years. Management-worker problems of a similar magnitude arose in cases 3, 5, 9, and to a lesser extent in the other cases.

Most of these arose from misjudgments by managers when introducing CNC or changing the way it was used at a later date. This shows that even where a workforce is willing to co-operate with the use of CNC, this co-operation can be lost, and the benefits from CNC diminished, by poor planning and lack of consultation.

The values, attitudes, self-interest and power of those involved: The importance of these factors was evident in all the case studies.

In case 1, the Technical Director's values and attitudes caused many of the early problems, but it was in his interest, and in his power, to ensure that the blame was placed elsewhere. In the same study, the programmer's interests lay in preventing the setter-operators from programming, and he was able to achieve this by influencing the Technical Director to use his power to support him. The programmer in case 4 acted in a similar fashion.

In case 3, the Managing Director's values and attitudes led him to believe that his interests would be best served by using CNC to deskill and control his workforce. However, he was thwarted in this, partly for technical reasons and partly because his workers demonstrated that they were not without power. They showed that without the willing co-operation of a stable workforce, the company would continue to experience severe problems: in this instance, their power lay in their ability to leave the company.

Other examples of managers, supervisors, and engineers whose values, attitudes, self-interest and power led them to advocate or try a particular form of work organisation, only to be met by resistance from workers, can also be seen in cases 5, 8 and 9.

In cases 6 and 7, the programmers were able to overcome the values and attitudes of their superiors in order to benefit themselves, which shows that it is possible for subordinates, regardless of their formal position, to exert influence, and therefore power, over their superiors.

It can be seen in all the case studies that the interplay of these four factors - values, attitudes, self-interest and power - was crucial in shaping the outcome of the change process. This does not mean that other factors did not act as constraints, but that within these constraints, and sometimes by ignoring or evading them, these four factors were paramount. This accounts for the fact that in a number of cases, managers and others were willing to settle for forms of organisation which were inefficient.

Having examined the internal factors, it now becomes easier to examine the external ones.

EXTERNAL SPECIFIC FACTORS

The external specific factors which were put forward as influential are as follows:-

Product market: As already mentioned, in all cases, the companies' market position was such that it drove them to introduce CNC as a cost-cutting/performance-improving device.

Labour market: The most notable labour market feature was the high incidence of unemployment in South Yorkshire. This meant that there was no shortage of skilled labour for conventional machines, though this did not prevent some managers citing the possibility of a future shortage as part of their justification for introducing CNC. Nor did there appear to be a shortage of workers with CNC experience, or who were capable of being trained for CNC. The ease with which the companies in cases 2, 3, 4, and - after some initial problems - 5 recruited or trained labour bears testimony to this, and once again casts doubts on the competence of the managers in cases 1 and 9 who had difficulty in recruiting or training labour.

However, it is difficult to say exactly how the high incidence of unemployment affected the introduction of CNC. Nevertheless, it does seem reasonable to argue that this, coupled with the redundancy situation in each company, did reduce both the work-forces' bargaining power and their willingness to confront their particular managements. Nor does it seem unreasonable to assume that this factor may have encouraged managers to introduce change with less consultation than might otherwise have been the case.

Availability of technology: In the instance of CNC, the companies had no difficulty with technology availability; indeed, perhaps the problem was almost the reverse. As mentioned in the introduction to this Thesis, there has been a great deal of publicity urging companies to adopt new technology if they wish to stay in business. As regards CNC, it has been impossible, for some years now, to open an engineering journal without being faced with advertisements for, or articles advocating, CNC. CNC purchase has been further encouraged by government grants totalling one third of the cost price. In these circumstances, it is not surprising that CNC was seen as the next generation of technology for the nine companies involved in this study. However, as mentioned before, whilst for the engineering industry in general this may be true, in specific cases it may not. Companies therefore need to examine their individual circumstances and needs. For the companies in this study, it appears that the - perhaps - "over"-availability of CNC blinded them to the need to carry out such an examination.

External general factors

The external general factors which were put forward as being influential were as follows:-

The nature of the political economy
Culture
History and development of societies
Ideology
Social institutions
Political stability
State of technological development.

As mentioned in Chapter 4, it was never the intention, nor was it possible, that the empirical studies should examine these factors. However, it was felt that the general conclusions drawn rom an examination of these factors could be tested by the vidence from those case studies.

The conclusions were that:-

a) in Britain, there had been a long-run tendency for organisations to develop along the lines prescribed by Scientific Management;

b) this tendency could be either exacerbated or moderated by contemporary economic or social developments;

c) at the moment, the state of the British economy would tend to exacerbate it, with the consequence that new technology would be used in a Tayloristic manner.

The evidence from the case studies would seem to indicate that these conclusions are correct. It was certainly the case that most of the companies, especially the large and medium-sized ones, exhibited Tayloristic tendencies, which were incorporated not only in the structures and practices of the companies, but also in the values and attitudes of many employees. It also appears to be the case that the present economic situation had exacerbated Tayloristic tendencies, in that companies were seeking to use new technology to cut costs, mainly by displacing labour, and that workers' ability to resist this had diminished as unemployment had risen.

Therefore, insofar as research limited to the internal workings of companies can, the case studies appear to support the importance at this fundamental level of these external factors in influencing the introduction and use of new technology.

CONCLUSIONS

This Chapter has compared the nine case studies and has also examined the conceptual framework in the light of these. The empirical research has shown that the conceptual framework, based as it is on an extensive review of the literature, is a relevant and valid device for understanding the impact of technical change upon job design and work organisation. This is true even though some factors, especially the external ones, were not, and could not be, examined by the direct evidence from the case studies alone.

Nevertheless, the general proposition that the introduction and use of new technology would be influenced by a wide range of factors, both internal and external to organisations, has been borne out. In particular, the role of Scientific Management beliefs and practices; the financial situation facing the organisations; the rigidity, or otherwise, of company structures and practices; the limitations imposed by the type of products being manufactured; and, crucially, the values, attitudes, self-interest and power of those involved, have emerged, in these case studies at least, as key factors.

However, two other factors not originally considered also come to the fore.

The first of these is that those responsible for buying CNC appeared to be "dazzled" by the fact that it was a, well-publicised, "New Technology". This caused them to assume, almost unquestioningly, that CNC was an appropriate technology for them and that it was also essential for their future survival. The result of this was that, in a number of cases, CNC may not have been the most appropriate choice, and may not have fulfilled their unfounded expectations.

This leads on to the second factor: the level of competence of those responsible for directing the introduction and use of CNC. In all the case studies, examples of incompetence were present, but this was especially so in cases 1, 3, 8 and 9. It was not simply that in some cases managers, engineers and supervisors put their own interests above those of the company, though obviously this did happen. The incompetence arose in the failure or unwillingness to analyse problems properly and to put forward and implement adequate solutions.

Therefore, the conceptual framework needs to take account of the "dazzle" and competence factors. Nevertheless, as stated, the original framework has been supported by the empirical evidence.

However, it is not sufficient merely to understand what factors influence the change process. It is also necessary to understand how this process can be improved, both from the viewpoint of the organisation and from that of those in the organisation who have to live with the results of the change. Therefore, in conclusion, the following guidelines for the introduction of CNC, and perhaps with certain modifications for other forms of new technology, are proposed.

1 Organisations need to carry out a rigorous investigation of their need for new equipment, which should include comparisons between all the alternatives available rather than just one.

The assessment should examine not only the economic and technical aspects of change, but also the human consequences in terms of changes to jobs. This process should involve trade unions/workers at an early stage, not only to gain their commitment to the change process but also to draw upon their knowledge of existing production methods and practices in the organisation.

Whilst large organisations should have the expertise available to carry out such assessments, the same cannot be said for smaller organisations. Therefore, it would be appropriate for some form of government assistance to be given in this area, especially as the government already offers grants towards the purchase cost of new equipment.

2 Trade unions should encourage and provide more positive assistance to their members who are faced with the introduction of new technology. Eight of the companies studied were trade union-organised, yet in only one case did the unions attempt to influence the change process. Whilst one important reason for this was the despondency brought about by the employment situation, another was a lack of knowledge of the technology and its consequences. Therefore, despite existing trade union efforts through such devices as training courses for shop stewards, more support and advice needs to be made available; especially if, as advocated above, trade unions are to become more involved in the assessment process.

3 Before and during the actual introduction process, a number of points need to be taken into account:-

i) The process should be planned by the company, along with trade unions, and should not be allowed to take place in a haphazard fashion. This should take account of the formal and informal organisation of work.

ii) Full training should be given to those involved and affected by the new technology. The experience of the case studies is that one or two months after the initial training, a further period of training, when those involved are more familiar with the demands and potential of the technology, should be given.

iii) In deciding upon job content and the organisation of work, companies need not only to take account of the limitations placed upon them by existing structures and practices and by their products, but also to recognise that the best results are achieved when those involved are motivated by and committed to the change process. Only in this way will flexibility and teamwork - which are essential with CNC - be achieved.

iv) Short-term financial advantages need to be weighed against hidden and long-term disadvantages. Examples of this are where poor job design is adopted in order to minimise direct wage costs, but where this in turn leads to poor quality, delays, high labour turnover, and accidents; or where an output bonus system is adopted which raises output but reduces quality. These are problems that can be overcome by employing skilled, well-paid, operators who are motivated to produce good work and reduce production delays.

4 Even after the initial form of CNC organisation has been adopted and is, hopefully, working successfully, it should be appreciated that the purchase of additional CNCs or changes of personnel over time will lead to other changes. Therefore, the more flexible and committed the workforce, the easier it will be to accommodate further change.

These are not comprehensive guidelines - such detailed advice can only be drawn up with a particular organisation in mind - but they do emphasise the lessons learned from the case studies. These are that planning and commitment are needed in order to optimise the technical, economic and human aspects of the organisation of work and bring about the successful use of new technology.

At the moment, for most organisations, the adoption of new technology is still in its infancy; therefore, the scope for choice is still there. This research has shown that economic and technical factors are not barriers to the creation of good jobs - rather the reverse. Only by creating jobs which embody skill, variety and autonomy, thus establishing a stable and well-motivated workforce, can organisations obtain the full technical and economic benefits of new technology.

Nevertheless, a major barrier to the creation of worthwhile jobs and the realisation of these benefits does exist. This is the continuing influence of the philosophy and precepts of Scientific Management upon management practices. Only when this influence is removed will it be possible to say that the impact of new technology will lead to better rather than worse job design and work organisation.

Hopefully, by exposing what actually happens in organisations and the counter-productive nature of Taylorism, this research ill contribute to its removal.

APPENDIX

INTERVIEW SCHEDULES

The following are a sample of the interview schedules that were used in carrying out the nine case studies. In most cases, they are designed to open up areas for further discussion rather than to elicit, as such, a specific response. It is also the case that, whilst these schedules indicate the areas of questioning that took place in all companies, the actual questions asked could, and did, vary from company to company and from individual to individual, depending upon the circumstances. As an example, in the small companies, the questions on structure and size were relatively straightforward and could be answered by one person; whereas in the larger companies these questions were more complex and tended to extend beyond the ability of one individual to answer them all. The same qualification must be made regarding the people questioned. In small companies, a person's job might cover a wide range of functions; whilst in the larger companies these functions could be, and were, performed by several people operating in separate departments. Also, the knowledge of individual interviewees varied; in some companies, managers, say, might be extremely well-informed of the activities of other areas than their own; whilst in other companies they might not even be particularly well-informed about their own area.

Therefore, the separation of managers' questions from supervisors' questions, and so on, is somewhat artificial, and in practice, the areas of questioning were wider than perhaps the individual schedules might suggest.

It should also be pointed out that though seven of the companies had already introduced CNC when the studies began, two had not. Therefore, in the latter two instances, the questions were somewhat different, whilst covering the same areas, from the former.

It was also the case that when return visits were made to each company, the questions became even more tailored to the particular developments taking place, rather than being of a standard format.

Nevertheless, the following interview schedules, with some modifications in each case, were used in order to build a picture of the events in each company surrounding the introduction and use of CNC.

MANAGERS' INTERVIEW SCHEDULE

1 Personal details: job title, functions, previous work history and experience, etc.

2 Company details:

i) Numbers employed

ii) Structure (organisation chart)

iii) Products and markets

iv) Ownership

v) Company history.

3 How has the company been affected by, and how has it responded to, the recession?

4 How many CNCs does the company have, and what type are they?

5 When were they bought and how much did they cost?

6 Why did you buy your first CNC(s)?

7 Why did you buy subsequent CNCs?

8 Describe the process for assessing and recommending the purchase of the CNCs.

9 If written purchase justifications were prepared, is it possible to examine these?

10 Which department of the company are the CNCs installed in?

11 What is the structure and importance of this department?

12 How long did it take to bring the first CNCs into full production?

13 What were the problems that arose in the introduction process?

14 Were there any subsequent problems with these CNCs?

15 How long did it take to bring the subsequent CNCs into full production?

16 What problems arose when introducing these further CNCs?

17 How is work organised around the CNCs? i.e. who is responsible for:-

i) supervision
ii) programming
iii) setting
iv) operating
v) inspection
vi) maintenance?

18 Did this change with the introduction of subsequent CNCs?

19 Is this the same form of organisation as the rest of the department?

20 Has CNC led to any organisational changes within the department or within other departments?

21 How were staff selected for CNC work?

22 Have there been any staff changes among those involved with CNC since they were first introduced?

23 What training did staff receive for CNC?

24 Was the training adequate?

25 What is your involvement with CNC?

26 Have the original objectives in buying CNC been met?

27 Have any unanticipated advantages/disadvantages emerged?

28 Do you believe that CNCs are the best method of manufacturing your products, or are there other production methods which would be better?

29 Do you believe CNC has been a success?

30 How has CNC affected the supervisors' jobs? Does CNC:-

i) make their job easier/harder?
ii) increase/decrease their control over production?
iii) increase/decrease their contact with CNC operators relative to other machinists?
iv) increase/decrease their need for technical knowledge of the production process?
v) increase/decrease the importance of their man-management skills?

31 Is the programmer:-

i) solely responsible for programming or is anyone else ever involved?
ii) ever involved in proving programs or setting and operating the CNC?
iii) involved in any supervisory duties?
iv) responsible for any duties other than those related to CNC?

32 In relation to their counterparts on conventional machines, do the CNC setters/operators:-

i) have more/less control over their work?
ii) have a more/less varied job?

iii) have a more/less skilled job?

iv) have a physically easier/harder job?

v) have a mentally easier/harder job?

vi) have a more/less interesting job?

What trade unions are active in the company and which sections of the workforce do they organise?

Were the trade unions involved in the assessment and introduction of CNC?

What attitude have they taken to CNC?

Has there been any change in management-worker relations in recent years?

Has CNC affected management-worker relations?

Does the company have any plans to acquire more CNCs, and if so, when do they intend to do so?

What other new technology has the company introduced, or thought of introducing?

Do you consider this a good company to work for?

SUPERVISORS' INTERVIEW SCHEDULE

1 Personal details: job title, functions, previous work history and experience, etc.

2 Why did the company buy CNC?

3 Were you involved in its pre-purchase assessment or its introduction?

4 How did you view CNC when it was first introduced?

5 How do you view CNC now?

6 What were the problems that arose in the introduction process?

7 Were there any subsequent problems with CNC?

8 What have been the advantages/disadvantages of introducing CNC?

9 Do you consider that CNC is the best method for manufacturing your products, or are there other production methods which would be better?

10 How is supervision organised in your department?

11 Has this been affected by, or has it changed since, the introduction of CNC?

12 What training did you receive for CNC?

13 Do you consider your training was adequate?

14 Describe your involvement with CNC.

5 Does CNC:-

i) make your job easier/harder?

ii) increase/decrease your control over production?

iii) increase/decrease your contact with CNC operators relative to other machinists?

iv) increase/decrease your need for technical knowledge of the production process?

v) increase/decrease the importance of your man-management skills?

16 Are you as confident in supervising CNC as the other machines in your department?

Questions 17 to 24 as per questions 31 to 38 on the Managers' Interview Schedule.

25 Do you like your job?

26 Do you consider this a good company to work for?

PROGRAMMERS' INTERVIEW SCHEDULE

Questions 1 to 9 as per Supervisors' Interview Schedule.

10 Why were you selected to programme?

11 What training did you receive?

12 Was the training adequate?

13 How long did it take you to become competent/confident in programming CNCs?

14 Does anyone else ever programme?

15 Do you also prove out the programs?

16 How many different types of CNC control systems do you have to programme?

17 Describe in detail the procedure for writing and proving out a new program.

18 How many programs are there in total?

19 Are you still adding new programs to this number?

20 What is the split of functions between you and the supervisors?

21 As per question 30 on the Managers' Interview Schedule.

22 What is the split of functions between you and the CNC machinists?

23 As per question 32 on the Managers' Interview Schedule.

Questions 24 to 27 as per questions 26 to 29 on the Managers' Interview Schedule.

Questions 28 to 34 as per questions 32 to 38 on the Managers' Interview Schedule.

35 Do you like your job?

36 Do you consider this a good company to work for?

CNC MACHINISTS' INTERVIEW SCHEDULE

Questions 1 to 9 as per Supervisors' Interview Schedule.

10 Why were you selected for CNC work?

11 What training did you receive?

12 Was the training adequate?

13 How long did it take you to become competent/confident in operating CNC?

14 Details of products/programs:-

i) What type of products are made on your CNC?

ii) What is the batch size?

iii) How long does it take to set up?

iv) How long does it take to produce each component?

v) Time per batch?

15 Describe in detail the procedure you follow when you receive a new program.

16 Describe in detail the procedure you follow when you receive a program that has been produced before.

17 What is the split of functions between you and the programmer?

18 Who do you go to if a problem arises?

19 Do you do your own inspection?

20 As per question 32 on the Managers' Interview Schedule.

Questions 21 and 22 as per questions 28 and 29 on the Managers' Interview Schedule.

Questions 23 to 28 as per questions 33 to 38 on the Managers' Interview Schedule.

29 Do you prefer working CNC to conventional/automatic machines?

30 Do you like your job?

31 Do you consider this a good company to work for?

TRADE UNION REPRESENTATIVES' INTERVIEW SCHEDULE

1 Personal details: job title, functions, previous work history and experience.

2 What union are you in and what position do you hold?

3 How many unions are there in the company and how are they organised?

4 Do the unions have any formal or informal agreement to work together?

5 Have there been any changes in management-union relations in recent years?

6 When were you officially informed that the company was buying CNC?

7 Is it, or has it been, practice for the company to involve the unions in the assessment/introduction of new equipment?

8 Had you any previous knowledge of CNC?

9 What were the main issues from a union perspective regarding CNC introduction?

10 How has CNC introduction affected your members?

11 In the areas affected, what was/is your members' view of CNC?

12 In retrospect, do you think CNC has been good/bad for your members and for the union?

13 Have you or any of your members attended a TUC course on new technology?

14 Did you receive any outside help in negotiating the introduction of CNC?

15 What assistance would you have liked?

16 Have you got, or tried to negotiate, a New Technology Agreement?

17 What other forms of new technology have been introduced?

18 What is your union's policy regarding new technology?

19 How do you regard new technology?

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