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TECHNICAL CHANGE AND WORK ORGANISATION

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Technical Change and Work Organisation

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Summary

This thesis is an exploration of the social and political processes involved in the introduction of new technology to the shopfloor. Through a series of case studies of applications of microelectronics to batch manufacture, it attempts to uncover the ways in which the values and interests of managers, engineers, workers and others profoundly influence the choice and use of technology, and thus the work organisation which emerges.

Previous analyses have tended to treat new technology as if it had "impacts" on work organisation - especially skills - which are inevitable in particular technical and economic circumstances. It is in opposition to this view that technical change is here treated as a matter for social choice and political negotiation, the various interested parties to the change being shown to attempt to incorporate their own interests into the technical and social organisation of work.

Section one provides the relevant background to the case studies by summarising and criticising previous theoretical and empirical work in the area. The inadequacies of this work for our concerns are drawn out, and the need for detailed studies of the political aspects of technical change is justified. The case studies are presented in section two as a set of "episodes" of innovation, and section three analyses the empirical findings. The innovations are compared and contrasted in order to illustrate the social and political dynamics involved in the various stages of the innovation process. Finally some comments are made on policy issues for which the research has important implications.

Keywords

work organisation
technology
innovation
politics

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INTRODUCTION

Electronic controls for production processes have increasingly been implemented throughout manufacturing industry over the last few years, and with microelectronics becoming cheaper and more powerful the range of their possible applications is still being extended. This thesis addresses not the quantitative employment aspects of this new technology, but rather the qualitative aspects - the ways in which the organisation of work is changing on the shopfloor. Systems of payment and shiftworking, relations between workers and managers, and most especially the tasks carried out by workers, are all changing - often in radical ways - and what follows is an attempt to come to terms with the nature of the relationships between work organisation and changing technology.

The literature on the social aspects of the new technology is now becoming extensive. However, few researchers have so far addressed themselves to exactly what is happening on the shopfloors of British industry as more and more firms find uses for microelectronics. This thesis is an attempt to uncover what is going on on the factory floor, and does so by means of a series of detailed case studies of innovations based on microelectronics in batch engineering. (This focus on batch production obviously means that some conclusions drawn are specific to this section of industry. However, many of the findings are relevant for production technology in general.)

The case studies were carried out between the autumn of 1979 and spring 1981 in the West Midlands - Britain's "manufacturing base" - and the project was located in the Technology Policy Unit of Aston University, the "technological University" of the Midlands. Thus the setting for the research was ideal.

The popular conception of innovation sees scientific and technological advances as having inevitable "impacts" on society, which may be good or bad, and which may be intended or unintended. Where this perspective has been applied to the workplace the changing skill structures, shift patterns, and so on, have been treated as "adjustment problems", and attention paid to how best to adapt to the new work organisation and working conditions. This naive but widespread approach, for reasons elaborated in chapter 3, has been deliberately avoided, and instead the managers, engineers and workers involved in technical change have been shown to take an active part in what is essentially a political process. The perspective adopted could probably best be described as pluralist, in that technological choice and the establishment of working practices are seen as contested. The perceptions and interests of the various parties to the introduction of new technology are explored, and shown to play a central role in the emergence of new work forms.

Because of this emphasis on the dynamics of change, the thesis does not forecast changes or depict scenarios. Rather, it shows how managers, engineers and workers can -

and do - become involved in directing the "impact" of new technology. In other words, we do not attempt to predict the future for work, but we do point out how one might intervene and influence that future.

The style of presentation is the one common to most empirical studies, with the theoretical background preceding the empirical findings, which are followed by the conclusions.

There is no established "body" of literature on technology and work organisation, although a wide variety of disciplines and sub-disciplines - from engineering to economics to sociology - provide relevant material. In section 1 I attempt to draw out the inadequacies of this work for our specific concerns in a summary and criticism, and the drawbacks are used to aid the formulation of the research aims.

Section 2 is descriptive of the case studies, and provides only limited analysis. This means that to some extent they can be interpreted in different ways, and different conclusions may be drawn. However, the case studies do reflect the underlying concern with political processes, and this places some order on the descriptions. In particular, the case studies are presented as a series of "episodes" of innovation, and attention is focussed upon the ways in which interested individuals or groups try to impose their own designs at the various stages of the innovation process.

In section 3 the innovations described are compared and

contrasted in order to illustrate the social and political dynamics involved in technical change. The various "stages" of innovation - design, trial, debugging, etc., are shown to provide junctures at which actors can influence the direction of changes. Finally some policy issues for which the conclusions have implications are addressed.

Three final points should be made on the style of presentation. First, each chapter is quite self-contained, and where this is not the case is clearly indicated and reference made to other relevant chapters. Thus for the most part chapters can be read independently. Secondly, footnotes and references for *each* chapter come at the end of the thesis. This has the advantage of leaving an uncluttered text, but the disadvantage of frequent reference to the last few pages. Footnotes for some chapters - especially the case study chapters - are quite important, and the serious reader is urged to use them. Thirdly, the dominant use of "he" throughout the thesis reflects the culture of the West Midlands engineering industry rather than the author's biases. The use of "person", etc. would simply take away too much from the flavour of the social milieu under scrutiny.

CHAPTER ONE

FOUNDATIONS

SECTION ONE

THEORETICAL BACKGROUND

CHAPTER ONE

WORK AND TECHNOLOGY

Technology and Industrial Behaviour

In the 1950's industrial sociology and psychology was beginning to identify technology as the primary variable in explanations of industrial behaviour (1). The areas to which this new independent explanatory variable was applied were as diverse and numerous as the precise definitions of technology employed (2). However, bearing in mind the simplifications involved in over-generalising, it is important to note the common feature of this work: "...all endow it (technology) with a primary explanatory value, whether they are examining psychological deprivation, the level of intra-plant conflict, management effectiveness or alienation: in so far as a technology demands a typical pattern of organisation (....) it creates role-determined behaviour" (3).

On the nature and level of industrial conflict, Kuhn (4) has argued that "fractional bargaining" - i.e., informal conflict within the workplace - depends on four aspects of production technology: regular changes in work methods and a high degree of interaction among workers stimulate fractional bargaining; the grouping of the labour force into equal departments weakens the political authority of the union and thus decreases the chances of official union involvement; and the sequential processing of materials into a single end product enables costly disruptions. Kuhn concludes that "...the less pronounced these characteristics

are in a production technology, the less important should fractional bargaining be" (5). Similarly, the "disruptive potential" a work group may possess by virtue of its position in relation to the firm's technology has been pointed out by Mick Marchington. A group is more likely to possess control if its work is "pervasive" - i.e., if interruption affects many other departments; and if its work is "immediate" - i.e., if interruption affects other departments rapidly (6).

On a wider level, most of the theorists comment, at least implicitly, on the ways in which the degree of class conflict, and/or the degree of "social integration" of the workers, are affected by changing technology. The arguments range from "automation eliminates class conflict" to "automation intensifies class conflict", and a detailed summary of the arguments of some of the main proponents has recently been presented by Gallie (7).

Management structure has been related to technology by Joan Woodward in her famous Essex studies: "...the main conclusion reached through this research project was that the existence of the link between technology and social structure....can be demonstrated empirically" (8). Spans of control of supervisors, the ratio of managers to total personnel, graduate to non-graduate ratios, the degree of delegation of authority, production control procedures, and so on, were all related to the dominant production technology of a sample of firms, and found to vary accordingly. She reported two main conclusions. First, some important organisational characteristics display a direct relation

to technical advance: the length of the line of command increases; the span of control of the chief executive grows larger and that of middle management becomes smaller; decreased labour-intensity means more money available for employee welfare, services, personnel specialists, etc.; the ratios of managers to total personnel, direct to indirect labour, and graduate to non-graduate supervision, all increase. Second, there are similarities at the extremes. In both unit/small batch production and process (automated) production there are: small spans of supervisory control; more skilled workers employed; "organic" management systems (flexible and participative); simple production control procedures; verbal rather than written communication between departments.

On psychological "deprivation", the most common technology to which authors refer is the assembly line, and accordingly the classic work on this aspect is Walker and Guest's submission of 1956 (9). The main conclusions are unsurprising: machine-paced work, repetitiveness, lack of challenge, etc., are the most disliked aspects of the job, and the wages the most satisfying aspect. Also the layout of the line prevented frequent social interaction - another deprivation.

In a similar vein, and drawing largely from Walker and Guest and similar works, Seeman (10) and later Blauner (11), have related production technology to the degree of "alienation" experienced by the worker. Blauner's work, in contrasting work experiences under different technologies, has been

particularly influential, and the next section will discuss his main thesis in detail. In doing this we can assume that Blauner's work is generally representative of the school outlined above, at least in the sense that technology is presented as a powerful independent influence on worker attitudes and behaviour. Thus many of our criticisms of Blauner will be applicable more generally.

We should finally briefly mention that just as the dependent variable (alienation, strike proneness, etc.) can be changed around, so can the independent variable. In particular, there is a similar (though smaller) school of theorists who give size of organisation the same explanatory powers as the above authors give to technology, and there is some debate as to which is of foremost importance (12).

Technology and the Experience of Work

For Blauner, varieties in the social organisation of work - and thus the experience of work - are related directly to the production technology of the firm: "...technology, more than any other factor, determines the nature of the job tasks performed by blue collar employees and has an important effect on a number of aspects of alienation" (13). As the dependent variable, he distinguishes four dimensions of "alienation":

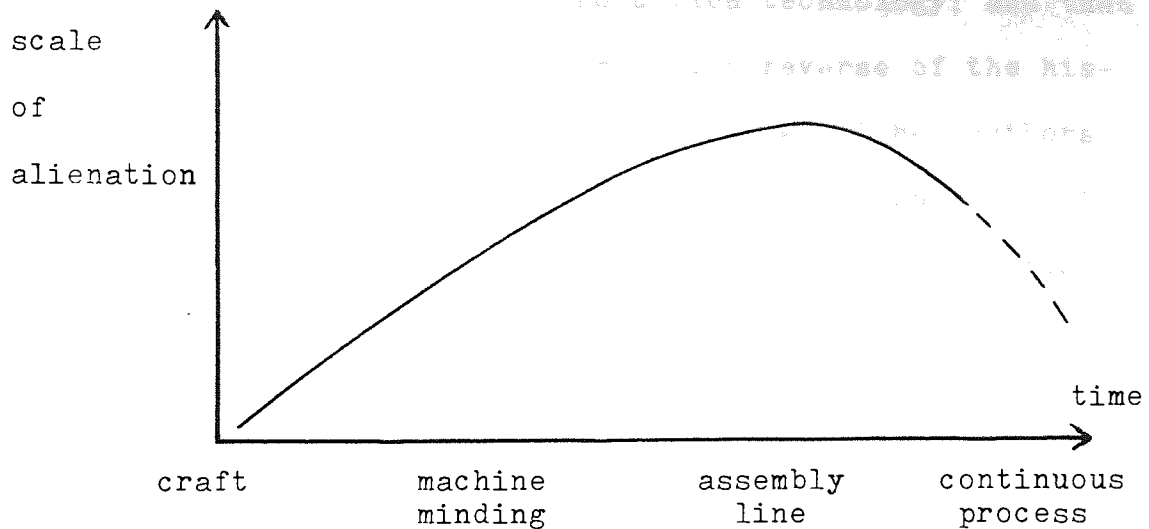
- i) powerlessness: a lack of control over work pace, work techniques, and the quantity and quality of production.
- ii) meaninglessness: this is induced when the work is

on a standardised product, only a small part of it, and when the worker has no responsibility for the product.

iii) social alienation: a lack of identification with the organisation and its goals.

iv) self-estrangement: experienced as a heightened awareness of time, when work is not free and spontaneous, but "driven simply by necessity".

These four dimensions of alienation are held to be causally related to the type of technology under which work is carried out, and Blauner presents empirical examples from the following four: craft (printing); machine minding (textiles); assembly line (automobile assembly); and continuous process (chemicals). These technologies are held to be generated historically, roughly in the order above, so that differences in work experience of the blue collar labour force can be expressed as a function of time. He concludes that: "Alienation has travelled a course that could be charted on a graph by means of an inverted U-curve" (14). (The U-curve is illustrated at the top of the next page.) The craft worker is portrayed as "free" and "in control": in particular, the work is done by hand rather than by machine, plants are small and there is little bureaucracy, and the product is non-standardised. The assembly line worker is



held to experience the most alienating conditions: the division of labour is intense, production plants have large and elaborate hierarchies, the product and work tasks rarely change, etc. (15). Finally, the continuous process worker experiences a return of the organisation of work to a less alienating form: variety of work is increased, control over the immediate work process is increased, and the workforce is divided into small "crews" responsible for particular sections of plant.

Some more recent research has attempted to modify the exact shape of the U-curve. In particular Tenne and Mannheim (16) have claimed that "semi-automated" technology allows greater satisfaction, job involvement and integration than fully automated technology; and J.C.Taylor (17) similarly draws attention to the possible effects (both positive and negative) of "in-between" technologies. This work, however, has left intact Blauner's two main conclusions: that work

organisation - and thus the degree of alienation - is directly dependent on the type of production technology; and that some automated technologies represent a reverse of the historical trend towards more alienating work. Other authors have attacked Blauner on the more fundamental grounds that his work vulgarises Marx's original concept of alienation. However, Blauner has defined his own version in sufficient detail for us not to confuse the two meanings, and we may thus discuss this criticism as a footnote (18).

Although Blauner's technological determinism is one of the most eloquently stated cases, his work, it should be repeated, is part of a tradition of analyses of this type (19), and certainly his optimistic treatment of automation is shared by many authors (20). That is, automated technology means that:

- i) routine activity is absorbed into the machinery.
- ii) sophisticated skills have to be maintained (but may be called into use less often).
- iii) the stochastic nature of work demands a large repertoire of responses from workers, an ability to respond without supervision, and a commitment to undertake tasks on their own initiative.
- iv) thus a high degree of commitment and autonomy is required.

Blauner summarises as well as anyone this new type of work and its implications:

"....automation increases the worker's control over his work process and checks the further division of labour and growth

of large factories. The result is meaningful work in a more cohesive, integrated industrial climate. The alienation curve begins to decline from its previous height as employees in automated industries gain a new dignity from responsibility and a sense of individual function...." (21)

We return later to the specific implications of automation and a fuller critique of Blauner's simplistic conclusion that automation represents a downturn on the alienation graph. For the moment it is worth introducing a note of scepticism by commenting that other determinists have measured opposite effects of automation. Rather than leading to more democratic, autonomous and responsible activities, it is held to lead to more centralised control, closer supervision, and more specialised tasks (22).

Orientations to Work

The most common criticism of the technological implications school, and especially of Blauner, is the assumption that workers desire or need "...opportunities for control, creativity and challenge...." (23). That is, there is a "...moral judgement....about the sort of work which ought to be satisfying" (24). Or, as Bechhofer puts it: "...both the classical Marxist view of alienation and a technologically deterministic view of worker satisfaction in its widest sense depend on making untested and general assumptions about the fundamental nature of man in his work" (25). Based on this criticism, by making the nature of man in work a matter for empirical inquiry, a series of studies have

attempted to show how attitudes to and behaviour at work are the result of "extraplant variables". That is, the sort of work experience any particular worker enjoys depends on what he brings to the work situation rather than what he finds there: "The way a worker receives and responds to any particular mix in the various aspects of work depends on the orientations he brings into that situation" (26).

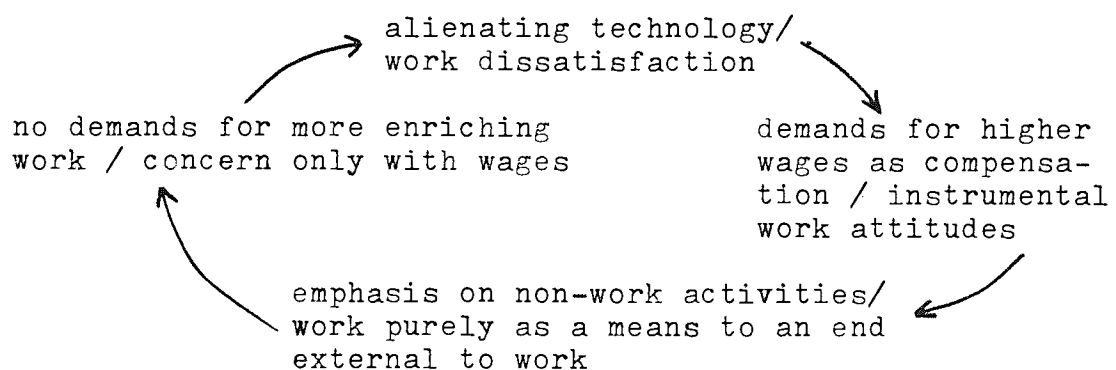
Most famous among these studies is that by Goldthorpe et al. (27). Here, attitudes to work are held to be determined by changes in working class life outside work. Through urban redevelopment, increased geographical mobility, the TV set, supermarket shopping, and so on, the traditional extended working class family has declined in importance. With the conjugal family dominant, working class life becomes "privatised", and the expectations placed on the breadwinner as provider, husband and father are strengthened. The primary motivations behind work become income and security of income, and this new "instrumental orientation" can be contrasted with the old "solidaristic orientation", where work implies "a whole way of life". Goldthorpe et al's study is of car workers in Luton, and they are contrasted with other industrial workers who have been studied in more "traditional" contexts. The car workers are held to represent the typical workers of the future as working class life outside work comes to be more and more privatised.

Turner and Lawrence (28) similarly contrast the different work aspirations of workers who live in city and rural locations, suggesting that "rural workers" (those from

a town rather than a city background) preferred more challenging and skilled work than "urban workers", who expressed more satisfaction with work requiring less skill.

Other "extraplant factors" identified by this school include age, sex, race and marital status (29), and the list is presumably endless.

However, if extraplant factors can influence attitudes to work, then so can aspects of the work situation itself, and thus some sociologists have attempted to point out the importance of both internal and external factors: "...the final meaning of work is the result a process of interaction between the objective features of work and the expectations brought to bear on them" (30). One sociologist in particular has suggested a "vicious circle" of work dissatisfaction and instrumentalism (31):-



More recent work has returned attention to the workplace itself. Wedderburn and Crompton (32), for instance, once again stress the importance of technological constraints on worker behaviour, and Goldthorpe et al's approach comes under particular criticism for failing to locate workers

attitudes within the context of the work situation itself. That is, workers "attitudes" cannot be understood apart from behaviour on the shop floor. They miss the fact that frustration may be felt and the design of work resisted (33), and as Burawoy points out, they "...miss the adaptations workers make in order to compensate for the deprivations they endure" (34). Further, instrumentalism may itself be an expression of the dissatisfaction and frustration felt at work, and of the feeling of powerlessness to control one's own work organisation:

"The workers insist on being paid as much as possible not because they put wages (money and what it can buy) above everything else but because....workers can fight the employer only for the price of their labour, not for control of the conditions and content of their work." (35)

Ultimately, whether attention is focussed upon the work process itself or upon the experiences of workers outside work depends on whether one wishes to emphasise the unchanging human characteristics (what Marx called a "species essence") or the changeable aspects of mens' characters (what Goldthorpe calls "orientations"). For as Burawoy points out:

"The more we dissociate the experiences of workers outside work from the responses in work, the more we are forced toward postulating invariant human characteristics - that is, the more we are driven toward outlining a theory of human nature....of the potentiality inherent in the human species." (36)

We may also comment that the orientations approach generally fails to modify Blauner's determinism in the sense

that it leaves intact the notion that technology determines the objective character of the work experienced by the worker. That is, orientations are not held to affect the social relations in production systems - only the way they are perceived.

With the assumption that workers' interests (though not necessarily capitalists' interests!) do go beyond the cash nexus, a host of industrial and managerial sociologists since the 1920's have taken a consultative interest in the alienating tendencies of modern work. They have proposed - and occasionally helped to implement - measures to alleviate the worst effects of technology. These managerial theorists, particularly some of the most recent ones, begin to erode technological determinism through example, and thus provide an important input to any debate on the nature and effects of production technology. The next chapter will examine this work.

Another, equally important, corrective to deterministic conceptions of technology is the literature which attempts to locate technology itself within a social, economic and political framework. Technology becomes a phenomenon dependent on certain social processes, rather than an omnipotent independent variable. Here the work of Harry Braverman is especially important, and will take up much of the third chapter (37).

CHAPTER TWO

NEW FORMS OF WORK ORGANISATION

Theories of Human Nature

While the technological implications school were mapping out the social and psychological effects of production technology, another group of American writers were devoting attention to the nature of man in work. Representing a strong reaction to the model of man upon which Taylorism and scientific management rested, their writings asserted that man's needs in work went beyond the cash nexus. Thus modern work experiences were dissatisfying, and led to organisational dysfunction in the form of high labour turnover, lack of motivation, absenteeism, etc. These writers have been collectively referred to as the "organisational psycho-technologists" (1) - their views of the nature of man in work often being behind the new work organisations recommended by social scientists - and we will return to their ideas after a brief outline of Taylorism.

"Scientific management" was increasingly being applied in the factories of the industrialised world at the turn of the nineteenth century, and reached its heights in Ford's automobile production lines in the 1920's (2). As its leading ideologue, Frederick Taylor not only helped develop its practice, but also laid bare its philosophical foundations (3). Taylorism advocated four basic principles:

- i) The self-motivated men capable of being loyal to the organisation and its goals should be the

managers. These managers should secure a more efficient performance by workers through:-

- ii) dividing and sub-dividing tasks into more simple forms, and removing all "brain work" to the planning department.
- iii) using suitable production incentives - especially piecework.
- iv) forcing workers to comply through the use of strict rules and procedures.

Gilbreth later developed Taylorism by adding motion study to time study. The basic motions in work - e.g., reach, grasp, place, etc. - were identified, so that unnecessary activities could be eliminated, and the essential ones measured by a stopwatch. Task sequences giving the highest productivity and the least fatigue could then be identified, and work operations conceptualised and measured in advance, so that "...workers are now viewed as all-purpose machines made up of so many motion units per unit of time" (4).

These "scientific" methods, by affording increased output and profits, were to make for a larger economic cake to everyone's benefit. They would also - and here Taylor makes clear his view of the nature of the worker - lead to more satisfying work:

"...the average workman will work with the greatest satisfaction, both to himself and his employer, when he is given each day a definite task which he is to perform in a given time, and which constitutes a proper day's work for a good workman. This furnishes the workman with a clear-cut standard, by which he can throughout the day measure

his own progress, and the accomplishment of which affords him the greatest satisfaction." (5)

Taylor's view of man as purely rational-economic was challenged as early as the 1920's and 1930's by Elton Mayo and the Human Relations schools of Harvard and Chicago (6). They "discovered" that man needs more than money from his work during the famous Hawthorne experiments in the 1920's (7). In Durkheimian fashion, they pointed out that informal group networks within the organisation were the result of attempts by workers to create a sense of identity within an increasingly "anomic" society. Management, then, should attempt to capture the "moral involvement" of the worker through securing commitment to organisational norms: firstly by integrating work group goals with organisational objectives - especially by basing incentive schemes on group rather than individual output; and secondly by making supervisors and lower management responsible for anchoring the group to the company with less strict styles of supervision. Management could thus help workers regain a sense of social identity, at the same time as reducing worker-management conflict, and taking productive advantage of the fact that workers tend to produce according to informal group norms (8).

Going beyond the human relations school, however, were those American writers referred to above as the organisational psychotechnologists. Their views of man's needs at work are based mainly on A.H.Maslow's famous "hierarchy of human needs" (9), which claims that as each level of

needs is satisfied, the next level comes into play - i.e., only when the lower-order needs are satisfied does man become concerned with the higher-order needs. Moving from the bottom to the top of the hierarchy these needs are: physiological needs - food, water, shelter; safety needs - avoidance of injury, insecurity, etc.; "belongingness" - the social needs which concerned the Human Relations school; esteem needs - status, respect, etc.; "self-actualisation" - the need to achieve one's potentialities. The two most famous industrial psychologists to develop and apply Maslow's model to the workplace were Douglas McGregor (10) and Frederick Herzberg (11).

McGregor suggests that the common form of work organisation in industry today assumes man's needs to include: clearly defined tasks; targets to be set by supervision; a hierarchy of authority; financial motivators; etc. In opposition to this "Theory X" view of man (and roughly speaking, Theory X is Taylor's view of man), McGregor urges managers to adopt a "Theory Y" view of man, where man's needs include: responsibility and control; undefined work tasks; loose supervision; to set one's own targets; etc. The Theory Y view, in making "self-fulfilment" especially important, closely corresponds to Maslow's view of "self-actualising" man. In order to accomplish the satisfaction of these needs, McGregor calls for job enlargement and the decentralisation of power.

Herzberg's "motivator" and "hygiene" factors similarly correspond to Maslow's higher- and lower-order needs.

Hygiene factors include salary, status, physical working conditions, and interpersonal relations. They are not positive sources of satisfaction, but their neglect can lead to dissatisfaction. The motivator factors are the positive sources of satisfaction, and they include the opportunities for achievement, recognition, responsibility and advancement - roughly, the top two levels in Maslow's hierarchy (12). Like McGregor, Herzberg called for job enrichment programmes as the solution to the ills of industrial work, and both contend that in creating satisfying jobs the workforce would be made more productive (13).

Job Enlargement, Job Rotation and Job Enrichment

The new management practices most commonly associated with the ideas of the organisational psycho-technologists are job enlargement and job rotation. Job enlargement refers, of course, to the combining of similar tasks in order to make a person's job "larger" - i.e., to make his work cycle time longer; and job rotation consists of moving employees at regular intervals between different jobs.

Rotating jobs is not, of course, a recent innovation. It has always been used in industry as a means of distributing more evenly particularly obnoxious work. Also in some circumstances the job of "utility man" may arise: substituting for absent employees the utility man rotates frequently between jobs. Similarly, job enlargement is hardly a novel practice. For instance, "doubling up" on assembly lines has commonly been used by automobile workers

in order to gain longer breaks from the job (14). The novelty of these practices, then, derive from the fact that they are systematic, management-initiated attempts to create more satisfying jobs.

Reports of successful experiments with job enlargement and rotation are commonplace. For instance, Miller et al. (15) and P.A.Hallam (16) report successful schemes of job rotation, and job enlargement schemes have been commented on by Biggane and Stewart (17), and Walker and Guest (18), to name just a few. David Birchall (19) provides a comprehensive summary of work in this area.

Alone, however, job rotation and enlargement are often considered insufficient even to relieve monotony. Indeed, Herzberg himself commented on these practices:

"(Enlargement is) adding another meaningless task to the existing one, usually some routine clerical activity. The arithmetic here is adding zero to zero.. ..Rotation is rotating the assignments of a number of jobs that need to be enriched. This means washing dishes for a while, then washing silverware. The arithmetic is substituting one zero for another zero." (20)

Further, daydreaming - possible on some highly repetitive work - may be interrupted, and patterns of informal socialisation may be disrupted through rotation (21).

Job "enrichment" - which implies the vertical enlargement of jobs to include indirect elements (planning, maintenance, inspection, etc.), and the delegation of more authority - has been advocated as a more radical solution to alienating work. (Of course, the dividing line between

enlargement and enrichment is one only of degree.) Paul and Robertson, for instance, report on the extension of responsibilities of a group of salesmen to include, for example, dealing with customer complaints, and varying (within limits) the prices they asked for goods (22). Similarly P.A.Hallam describes how a group of warehousemen were given the responsibility to supervise themselves at the same time as a comprehensive system of job rotation was introduced (23). Like most other studies of this ilk, increases in job satisfaction as well as economic benefits to the organisation in the form of increased productivity and/or decreased absenteeism and lateness, etc. are reported (24).

The first criticism to be made against these experiments is that they are often too superficial to make any radical impact on either the social or economic levels. In fact, the extravagant claims made by some of the researchers have been seriously called into question by several authors. For instance Srivastva et al., in a review of 600 empirical case studies, complain that the moral involvement of researchers leads to systematic biases:-

"Much of the literature is written with a missionary zeal which leaves the reader in no doubt about the bias of the writer. Bias could affect the validity of the findings in a number of ways: selection of research sites where success is particularly likely, biased perception of consequences, selective reporting of results, and the willingness of the subjects to please the researcher. We also have no information concerning

the fate of negative results." (25)

Here the "Hawthorne effect" - the excitement participants may feel when associated with new ventures - is particularly important, yet most studies fail even to attempt to disentangle this effect from the effects of the changed work roles (26).

A second criticism is that enrichment programmes operate within the limits of - or, more radically, are actually generated and implemented through - the exigencies of the capitalist system. These claims raise a host of questions, and they will be dealt with later in the chapter.

The third criticism - or at least, limitation - of these experiments, and the one which makes them relevant to our concerns, is the fact that they generally operate within the limits set by the technology: "The chief limitation on effective job enrichment for large sections of industry is the constraints imposed by the primary technology employed in the process of production...." (27). Cotgrove and his colleagues, reporting one of the more detailed case studies of job enrichment, make the point very clearly:

"Job enlargement plus less supervision had undoubtedly contributed to a marked decrease in boredom. And the work now made greater demands on abilities. But basically the work remained monotonous. Consequently, for most, work had little meaning. It was essentially a means to an end - a source of income. Although reorganisation had brought about some improvement, neither the tasks nor the product provided much basis for satisfaction or were seen as in any sense meaningful....In short, however significant the gains from organisational changes, the technology

in the last analysis set the limits to job enlargement." (28)

Thus the determinism of Blauner and the technological implications school discussed in the first chapter is left, basically, intact, with researchers tampering only with marginal organisational adjustments.

We can identify two responses to this state of affairs. The first is a disappointing regression into the belief that the advent of automation necessarily entails the re-design of jobs along more humane lines. Recently this notion has been incorporated in ideas of "post-industrial society", and demands further attention. The second response - and by far the most promising - is the attempt by some researchers to question the autonomous character of technology. Often under the guise of "socio-technical systems" research, they have begun to see the design and choice of technology as areas for practical intervention. We return to this radical departure shortly.

Automation in Post-Industrial Society

The hallmark of post-industrialism is the development of "sociologising" modes of productive activity in place of the old industrial "economising" modes (29). This change, if it could be demonstrated, would represent the solution to a problem occupying a host of social theorists since industry and capitalism first arose. The problem is, of course, the amorality of an instrumental society, and is probably best expressed by reference to the classic work

of Ferdinand Tönnies (30). Concerned with the opposition between "gemeinschaft" and "gesellschaft" (community and association), Tönnies maps an historical transition from community, where the intrinsic value of relationships are sought, to association, where the parties of the interaction remain indifferent to one another while trying to achieve instrumental purposes - as in the modern employment contract. The problem is how to return to communal modes of activities characteristic of pre-industrial and pre-capitalist societies (31). For Bell, the advance of technology magically creates new "sociologising" (communal) modes of activity:

"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 the services and amenities - health, recreation, education, and the arts - which are now deemed desirable and possible by everyone....(It) is also a 'communal' society in which the social unit is the community rather than the individual, and one has to achieve a 'social decision' as against, simply, the sum total of individual decisions...." (32)

Of course, Bell's discussion is society-wide, referring to the rise and fall of whole sectors of the economy - i.e., the rise of the personal service sector and the decline in importance of traditional consumer goods industries. On this level Jonathan Gershuny provides sufficient opposing empirical evidence at least to cast doubt on Bell's claims. Gershuny concludes that more important than "person-to-person" services - which in any case are being absorbed by the self-service economy (televised education, home

video machines, etc.) - are: recruiting new employees,

"....those service industries (distribution, banking, insurance, finance) which have to do essentially with the system of material goods and their ownership, and those service occupations (managers, technologists and other professionals) whose activities aid the improvement of the efficiency of the system of material production." (33)

Thus the restructuring of the economy is not necessarily a "post-industrial" restructuring.

Of more direct interest to us, however, is the application of the post-industrial ideal to the point of production - that is, to the way in which modern technology affects the work organisations characteristic of our factories and offices. Confusingly, there are two approaches to the development of the post-industrial workplace. The first sees the rise of the new values and needs associated with post-industrialism as leading to demands for more enriching work, and thus the development of new forms of work organisation. Job enrichment programmes and the like are thus presented as a recognition of, and response to, the fact that current conditions of work are dysfunctional because of their unfitness for human beings (34). Indeed, some reports openly state that job enrichment programmes were initiated because of the increasing disaffection of a workforce with higher expectations - expressed in terms of absenteeism, high turnover rates, lack of motivation in work, etc. Volvo's ambitious programme, for instance, was embarked upon "...in response to a high rate of turn-

over and increasing difficulty in recruiting new employees.. .." (35). Albert Cherns logically extends this line of argument in suggesting that new work organisation programmes are partly a result of the recent decline in the availability - and acquiescence - of immigrant labour (in Britain) and "guest workers" (in mainland Europe), who traditionally have filled the most arduous, dirty, and menial occupations (36).

The second approach, à la Blauner, sees the advent of automation as demanding post-industrial forms of work organisation. Davis and Taylor can thus refer to automation as a "post-industrial technology" (37). This technology demands an involvement in the control and regulation of work, rather than the performance of routine activities, which are now absorbed into the machine. The diagnosis and adjustment of malfunctions becomes particularly important, and thus "perceptual" and "decision-making" skills replace the traditional need for "motor skills". Perhaps the most important change is the transformation of traditional modes of supervision. Taylor suggests that:

"The trend with advanced technology is in the direction of supervisors doing less in the way of traditional management - supervising behaviours of others, attending to selection or training functions, and the like - and more in the way of acting as a facilitator, boundary controller, and communications link for the work group, or becoming technically skilled operators themselvesat more sophisticated levels of technology (automation), conventional notions of work and skills no longer apply. Workers, individually or in groups, supervise machines or processes,

so that the conventional notion of supervision is no longer applicable." (38)

Reinforcing these changes at the point of production, through banishing scarcity and creating "careers" rather than "jobs", automation is held to replace the traditional work ethic with the values of "self-actualisation" and "self-expression" (39).

To be fair to Davis and Taylor, they do suggest a flexibility in technical and social organisation which qualifies any deterministic effects. In particular, along with other socio-technical systems theorists, they see the design and impact of new technology as being coloured by management ideology. However, some are less optimistic than Davis and Taylor. Cherns, for instance, comments that although new automated technologies may provide new opportunities,

"....in the development towards a post-industrial society there are no automatically operating factors which will ensure that working lives will improve, or that future jobs will provide the worker with more control over his own work." (40)

Socio-technical Systems Research

Generally, the aim of socio-technical systems research is to effectively implement the type of work organisation described above by Davis and Taylor (41). However, the difference between this approach and other job enrichment attempts lies not so much in the nature of the end results sought (though some would claim they are more radical),

but rather in the means used. In particular, at least for the more ambitious theorists, the notion that technology sets definite limits on the organisation of work is discarded and replaced by the view that the design and choice of technology are themselves areas to be examined and manipulated in the job design process.

The important role of technologists and engineers in the job design process was recognised as early as the 1950's, and a report on the criteria they used in designing jobs appeared in 1955 (42). The prominent design criteria reported were: to achieve specialisation of skills, to minimise skill and training requirements, to make job content as specific as possible, and so on. However, experiments with new forms of work organisation tended simply to adapt the social organisation of work to the (given) technology in ways which would "optimise" both the technical and the social systems (43). More recently, though, some experiments - especially those involving new computer systems - have taken the technology itself as a matter for social choice.

The most famous example is the Volvo plant at Kalmar in Sweden, where technical flexibility is built into the production system with battery-powered assembly carriers which run on magnetic tracks in the floor. An alternative to traditional assembly line working, the new system allows "semi-autonomous work groups" to plan their own assembly tasks - enlargement and rotation being obvious alternatives to the traditional minutely specialised tasks of the auto-

mobile assembler. At the same time the use of buffer stocks - another "socio-technical" innovation - allows the teams of workers to vary their pace throughout the working day, rather than pace being determined simply by the speed of the line. Finally, the use of visual display units to provide work teams with information on quality variations gives them the opportunity to diagnose their own problems with work methods and adjust them accordingly (44).

Office work, much of which involves "soft" technology (i.e., where machinery and physical artefacts are less important than systems of organisation), has been shown in several recent case studies to be easily manipulated by changes in computer systems design. For example, Mary Weir reports cases where the labour of clerks was divided functionally, so that clerks dealt with only some aspects of many clients (e.g., data control, data preparation, output handling, query department). She shows how a simple redesign of the computer system could allow a geographical division of labour, so that clerks would deal with all the aspects of a particular set of clients (45).

Some recent experiments in West Germany are particularly interesting, where a new design strategy has been used by a team of production engineers at the University of Stuttgart. It involves engineers producing a list of alternative technologies, which are rated according to traditional economic and technical criteria. Then a team of social scientists and workers measure the alternatives

according to their social and psychological needs and expectations. A technology which scores high on both the "technical" and "human" scales can then be implemented (46).

In chapter 4 we shall return to the theoretical aspects of the radical notion that technologies are the subject of social choice. For the remainder of this chapter socio-technical experiments shall be given the same status as all the new forms of work organisation in an evaluation and criticism of the work.

Current European Experiments

It is probably worth digressing in order to point out exactly who has been involved in experiments with new forms of work organisation, and where they have taken place. The change agents can be divided roughly into three categories - private consultants (often academics), government-sponsored consultants (in Britain the Work Research Unit is especially important), and internal company personnel.

The importance of each, and the mechanisms by which changes are put into practice, vary from country to country. In West Germany, for instance, as part of the government's capital assistance programme for technological change and reorganisation in industry, a "Humanisation of Work" programme represents the major development (47). Grants for reorganisation are given to industry on the conditions that works councils participate in the change and that social scientists are allowed to conduct research into the change. The West Germans' is the most centrally-planned programme,

although some private firms who formerly participated now prefer to support their own schemes "...to avoid publicity and possible loss of competitive advantage" (48).

Scandinavia is the leader in European job design developments. Famous theorists like Trist, Emery and Thorsrud were involved in the early initiatives in Norway, placing a heavy emphasis on worker participation in the design of workplaces (49). Recently, however, Sweden has outstripped Norway in the extent of its programmes - the famous experiments at Saab and Volvo being particularly important. Employers have themselves been responsible for initiating programmes, and the Swedish Employers Federation (SAF) has played a coordinating and publicising role (50). However, in both Sweden and Norway government legislation on industrial democracy provides a context for the changes.

In France, as in most other European countries, initiatives have come from individual companies, and the government has had little direct involvement (51). Similarly in Holland, work restructuring has tended to originate from individual firms. Philips have been particularly important here, carrying out a range of job design programmes which affect several thousand employees.

In Britain also, the initiative has tended to come from individual companies - particularly those highly automated chemical and petro-chemical companies (52). Very few experiments involving significant numbers of employees, however, have been carried out even here. In fact the Work

Research Unit of the Department of Employment was set up in 1974 partly as a recognition of Britain's lack of interest in the job design scene. Coming under the auspices of a tripartite steering group of representatives from the Department of Employment, the CBI and the TUC, its brief is to provide industry with information and assistance on new forms of work organisation. The number of researchers and consultants employed is of course paltry compared, for instance, with the West German programme, and having no economic or legal muscle, one can only sympathise with attempts to make any impact in industry (53).

Assessment

Radical critiques of new forms of work organisation come on two levels. On the first, the claimed social and psychological impacts of experiments are brought into question, and "job design" is seen, at best, as a public relations exercise. An excellent example is provided by Keith Dickson's study of the automation of a production line, where the job enrichment programme was centred around the two activities found to be non-automatable (54). That is, enriching jobs was secondary to eliminating jobs. The "positive attitudes" of those few workers who remained on the line, the study makes clear, are probably more to do with the attention afforded them by management and engineers, and the increased pay grade, than with any great changes in the nature of their jobs. Similarly, Nichols and Beynon, in their study of a chemical plant, expose the enormous

discrepancy between the claims of job design theories and the actual practices in the workplace (55). Thus one worker in the study comments:

"You move from one boring, dirty, monotonous job to another boring, dirty, monotonous job. And then to another boring, dirty, monotonous job. And somehow you're supposed to come out of it all 'enriched'. But I never feel 'enriched' - I just feel knackered." (56)

This study is especially interesting for the way it displays how managers at the plant interpreted and implemented the ideas of the likes of Herzberg and McGregor, forcing one to realise how unconnected (or rather how indirectly connected) ideology and practice can be. Blackler and Brown provide another analysis on this level, attempting to play down the significance of the changes in Shell - perhaps Britain's biggest single experimenter (57).

However, the voluminous outpourings of radicals condemning management initiatives belie the argument that these developments are unimportant, or simply public relations exercises, and the second level of criticism accordingly affords them a greater significance. (This is not to say, of course, that the public relations aspects are not taken advantage of - they clearly are.) Changes in work organisations are seen as genuine attempts to alter the quality of jobs - the critique is of the motivations behind the changes, and the ends achieved in terms of increased profits or management gains in control. That is, management wish to increase satisfaction at work in order to motivate workers to work harder - a "happy" worker is a more productive

worker. And at the same time the changes are attempts to "integrate" or win the loyalty of the workforce - decreasing the threat of strikes, sabotage, absenteeism, and so on. Bosquet has referred to these changes as "mock socialism" (58), and Nichols as the "socialism of management" (59), indicating what is probably the biggest worry of radicals - the association of the changes with that unholy phenomenon, false consciousness. Using Marx's distinction between "technological" and "market" alienation (see chapter 1, note 18), C.Wright Mills had anticipated the problem twenty years ago: "Current managerial attempts to create job enthusiasm....are attempts to conquer work alienation within the bounds of work alienation. In the meantime, whatever satisfaction alienated men gain from work occurs within the framework of alienation" (60). In sum, the problem is that new forms of work organisation are subversive of the development of a "revolutionary" workers' consciousness.

That the underlying motives behind new forms of work organisation are primarily economic is difficult to argue with, and when authors do place the changes in their wider social and economic context (which unfortunately is not always the case) their significance becomes clear. For instance, changes in Sweden have occurred as a response to a more educated workforce with higher expectations, and a rapidly changing product market calling for higher flexibility of labour. Similarly in Germany, unemployment has given rise to the need to replace guest workers by German workers, who are not attracted to traditional assembly line

work. Lupton and his colleagues, in their review of changes throughout Europe, can thus conclude that:

"The reasons which prompted a concern to redesign manufacturing systems in radical ways have rarely included an explicit and single-minded commitment to a set of humane values. Rather, they have been piecemeal responses to events in labour markets and product markets with economic ends in mind..
..The process of 'humanising the work' has, therefore, mostly been a means to an end, rather than the end itself. The 'end' has variously been a need for production flexibility, to attract labour, to avoid revolutionary protest, or response to trades-union pressure, all with economic survival and/or development in mind." (61)

In this context the role of social scientists in industry has been criticised - their work being used by managers only to the extent that profitable use can be made of it (62). The fact that much of the literature - like that of the radicals - rejects the commodity theory of labour, is held to be insignificant in practice.

However, if it is too simplistic to see new forms of work organisation simply as humane attempts to increase satisfaction at work, it is equally simplistic to see them as no more than underhanded attempts by managers to manipulate workers. For it is surely a one-dimensional view which sees management at work as concerned solely with the pursuit of profits, just as it is a one-dimensional view which sees workers as concerned solely with payment. Our major case study of a machine tool manufacturer should be particularly enlightening on this point. Here, different sections of management are shown to hold different values

and ideals, which are translated into demands for corresponding forms of work organisation on the shopfloor (see chapter 11). In effect, the stances of managers in relation to forms of work organisation can be politically informed (63).

Further, some sociologists hold that experiments with new work forms can signal a more general change of direction for the firm. Bosquet (64), for instance, sees the changes as having a possible "mushrooming" effect, where control over the immediate work process leads to workers wanting more power and control in other, more contentious areas, such as capital investment programmes, the distribution of profits, and so on. In other words new forms of work organisation are seen as a preliminary to, or a precondition of, demands for industrial democracy.

In the end, much depends on the circumstances in each particular case. Especially, the motives and commitments of managers, and the degree of involvement of workers and their representatives will determine the nature of the changes in question. This has been recognised by Josep Bolweg, who in discussing experiments in Norway, shows how a lack of involvement on the part of trade unions or workers' committees could allow management to abuse the experiments - in one case using them as an excuse to improve production standards and introduce speed-ups (65). Daryl Hull goes further in taking up the issues from a purely trade union point of view in a discussion of five case studies of job redesign in Britain (66).

We should finally comment on the small number of "re-designed" jobs in Europe, and especially in Britain. Too much attention on these experiments may deflect attention from other, more important, developments in work organisation, which are occurring without the involvement of social scientists. Indeed, even within the firms in which "action researchers" have been involved, attention may have been given to the introduction of "autonomous work groups" and the like, while ignoring the degree of autonomy already secured by the initiatives of workers themselves, or by trade union defences of demarcations, etc. The case studies in this thesis hopefully show how work organisations are constantly negotiated by different groups of workers and managers, each with their own interests, and which must be understood in explanations of workplace forms. The job design literature, too simplistically, tends to treat the work organisation as a non-political entity, rather than as subject to an active political battle within the workplace.

CHAPTER THREE

TECHNOLOGY IN SOCIAL AND ECONOMIC CONTEXT

Introduction

In 1974 Harry Braverman published what has rapidly become a basic reference for students of industry - Labour and Monopoly Capital (1). His treatment of technology within the context of capitalist social relations marks a radical departure from the traditional industrial sociology discussed in chapter 1, and also from the literature which considers the possibility of the ameliorative treatment of the negative effects of technology discussed in chapter 2.

In rejecting the "new forms of work organisation" lobby, Braverman takes up - as we shall see, necessarily for his thesis to maintain its logic - a totally cynical position. In the face of the "deskilling" inherent in the development of the capitalist labour process, the literature is insignificant:-

"Since it focuses attention upon this long-neglected aspect of capitalist society, the current discussion of work cannot help but be useful, no matter how meager its results. But like most such discussions in which a basic characteristic of our society is 'discovered', accorded a superficial 'analysis', given a facile 'solution', and then once more forgotten, this one too has not begun to touch the roots of the matter. We are dealing with one of the fundamentals of capitalist society, and this means that even while slight ameliorations are accepted by corporations, the structure and mode of functioning of capitalism reproduces the present processes of labour a thousand fold more rapidly, more massively, and more widely." (2)

However, in order to illustrate the radicalness of Braverman's position in placing technology and the "labour process" - the way work is organised - in the context of the capitalist system, his thesis is probably best contrasted not with the technological implications school, nor with the managerial sociology of chapter 2. Rather, we will compare it with the literature which refers to changes in production technology as "innovation". The innovation approach, focussing on the economics of change, has a good deal to say in its own right, and will be dealt with before an exposition of Braverman.

The Economics of Technical Change

In chapter 1 we outlined the work which sees "types" or "levels" of technology as demanding particular patterns of work organisation, and thus having an independent influence on the experience of work and on aspects of industrial behaviour. These analyses generally fail to explore the origins of technology, in most cases taking it as the starting point of their study. If pushed, a form economic determinism is the most likely explanation for the development of the types of technology they identify - i.e., the technology represents the most efficient method of producing the goods or services offered by the firm: the social impacts are of secondary consideration; the necessary consequences of technology's own logical development.

Joan Woodward was one of the few who openly acknowledged a reliance on an economically deterministic model

in pointing out that for any given technology the most successful firms have a particular social structure. That is, success (and thus survival) depends on ensuring the organisation fits the technology. (Appropriate organisations for a range of technologies were outline in chapter 1.) The argument has been elaborated by a group of economists who see the development of technology in terms of a "process of innovation", and without wishing to oversimplify, the basic tenets of their conception of technology can be presented as follows (3).

The innovation approach begins with new ideas and their application: "An invention, when applied for the first time, is called an innovation" (4). Attention is focussed, in particular, on advances in scientific and technical knowledge, and the way they throw up possible useful applications. If application is successful, and generally this means if found economically viable, there begins a process of "diffusion" of the innovation. Individual firms are forced to "adopt" the innovation in order to remain competitive (i.e., in order to survive). The diffusion of the innovation then gives "impacts" which may be intended or unintended, and which may be good or bad. Throughout, new technology is treated as a neutral input to individual production systems, the motivation behind its introduction being purely competitive, and its effects, apart from the improvement of the competitive position of the firm or nation-state, being largely incidental.

Alongside this theory of change, and for the most part

barely distinguishable from it, is the literature which is directly applicable, and is often applied, in policy formulation and decision making. This literature maps out the conditions for success and failure, and points out how firms, industries, or whole nations, can innovate to maximise competitive advantage. For instance, the conditions under which successful applications (innovations) may arise from scientific and technical research have been explored; if insufficient attention is paid to the market, if investment is too low, or R&D poorly organised, etc., then viable innovations may not be forthcoming (5). Similarly, the rates of diffusion of innovations are affected by market structure, "attitudes to change", legal restrictions, etc., which act as "stimulants" or "constraints" (6). And of course, any negative impacts a new technology might have are treated as "adjustment problems" which must be dealt with if resistance to change is to be avoided. For instance, Mansfield discusses the problem of dealing with displaced labour - often an unfortunate consequence of automation: workers may have to be retrained for new jobs, or even moved to different parts of the country where work is available, etc. (7). Our concern is most centrally with any "impacts of innovation" at the point of production, and more detailed attention will be given to the literature which focusses on this aspect.

The "Impact of Innovation" at the Point of Production

In the 1960's a series of studies dealt with the effects of automation at the point of production in exactly the manner one would expect in following the logic of the innovation approach. The most famous of these is that by Touraine, published in 1965 (8). The "adjustment problem" identified lies in the transition from a "craft" to a "technical" system of work associated with the introduction of automated production processes. Automation is held to give rise to better physical working conditions, and reduced physical effort, but also to lead to boredom, and to tension from the stochastic nature of the work. It may also disrupt existing work group relationships. Resistance may thus be generated, but policies to overcome the resistance - especially in the form of early "consultation" and "participation" - may help smooth the implementation of the new technology.

Touraine's analysis and recommendations have since been modified (9), in particular by emphasising that the transition workers face is less likely to be from a "craft" to a "technical" system of work than from an "unskilled" to a "technical" system. However, the basic concerns remain the same: in order to avoid social and economic distress, and more importantly in order to effectively and speedily implement changes, adjustment techniques must be generated and employed. Both the need for change in the first instance, and the form the change takes, are taken as inevitable consequences of technological advance, and the best workers can do is to "adjust" and "adapt" themselves to the new

working arrangements.

Another set of policy studies which treat work organisation changes as the inevitable result of technological advance were those from the Science Policy Research Unit at Sussex University in the early 1970's. Using the simple deterministic model outlined above, the relationship between technology and skills in the engineering industry were analysed (10). Assuming that the physical characteristics of the technology determined the skill requirements of firms, they suggested that if the diffusion rates of particular types of technology could be forecast, and the "skill requirements" of each type assessed, then future changes in training needs arising from changes in technology could also be forecast. Individual firms, and more importantly national training boards, could then plan more accurately their training programmes with an improved knowledge of future manpower requirements. Management policies within individual firms are treated merely as obstacles to the logical development of the new technology and its associated skill structures, and like the workers in Touraine's study, managers are urged to adapt to the demands of the new technology.

The problems with this analysis have more recently been recognised by SPRU researchers themselves:

"....it does not seem reasonable to assume that management policies merely delay the impact of technological change on skill structures....the 'skill structure' of a particular (....) organisation is a function of manpower, training and job design policies,

as well as of the economic and technological characteristics of the organisation's activities....future research should be designed to take into account the extent to which both technological change and skill structures are affected significantly by company policies." (11)

Their research, however, has yet to fully abandon the assumptions of the innovation approach. Their most recent work tends to see the particular product, batch size, existing inspection system, etc., of individual firms as modifying the impact of technology, but the final outcome is still seen as that which enhances overall efficiency in the circumstances of the particular firm. No social and political motives are recognised, and forms of work organisation are still held to reflect the "one best way" for the set of technical circumstances in question (12).

An example of the "impacts of innovation" approach applied to office technology has recently been provided by Emma Bird in a study of the impact of word processors on female labour (13). Suffering from the worst problems of the innovation approach, "information technology" is presented as having "impacts" on clerical jobs, on equal opportunities, on training requirements, and so on, with little reference to ways in which these "impacts" may be at least modified by specific organisations.

The innovation approach is severely limited to the extent that it treats technology as devoid of any social and political context (14). Technology is held to arise somehow from scientific and technical research, and if it

so happens to confer competitive advantages then firms must either adapt and accept the consequences - the "impacts" - or go bust. The context in which technical change occurs is treated as of importance only to the extent that it constrains the changes, or is changed itself by the new technology. Thus instead of discussing, for instance, the nature and availability of skilled labour within a firm and the way this might affect the choice and use of technology, the skilled labour is treated simply as a possible constraint (as Touraine points out, craft workers may resist the new technology's demands) or as a phenomenon which is transformed by the technology (from "craft" worker to "technical" worker). The fact that managers may introduce technology with the intention of transforming the nature of work simply will not fit the "impacts of innovation" framework.

In depoliticising technical change the illusion of a consensus is achieved: it is in everyone's interest that the firm competes and survives, thus we must adopt the technology and its consequences, or else! In this sense the simplistic model of innovation can act as an ideological justification for particular changes which may have political as well as economic motivations, and in mystifying the real nature of technology its effect can be powerful. This does not necessarily mean that there can be no consensus at all - for in some senses there clearly is. For example, failure to update production methods may mean the firm makes a loss, goes out of business, and causes a good deal of unemployment - at least in the short term. It is this basis in

reality that makes the myth of neutrality so dangerous. But it does mean that any consensus must be limited, and it is thus one of the major tasks of this thesis to remove the consensual veil in order to display technology as a phenomenon controlled by particular people with particular interests and in particular positions of power. The questions which must be raised are such as "why does the change take on this particular form?", "which groups of people instigate the changes?", "for what purposes?" and "who are the prime beneficiaries?"

The most important recent work which challenges the neutrality of technology is that of Harry Braverman, and it will now be discussed at length.

Capitalist Technology and the Working Class

In relating changes in production systems within capitalist societies to the constant attempt to maximise profits (i.e., to maximise the surplus extracted from labour), Baran and Sweezy explain the rate and direction of expenditure on R&D, the rate of diffusion of new techniques, etc., in terms of the particular stage of development which capitalism has reached (15). The "impacts" of new techniques thus also find their source in the nature of capitalism, and these have been elaborated in Braverman's *Labour and Monopoly Capital*.

Braverman's starting point is the one common to most modern Marxists: when the worker enters into a labour contract, he sells not himself but his "labour power", and the

capitalist is left with the problem of realising the "full-
usefulness" of that labour power:-

"....when he buys labour time, the out-
come is far from being either so certain
or so definite that it can be reckoned..
..with precision and in advance. This
is merely an expression of the fact that
the portion of his capital expended on
labour power is the 'variable' portion,
which undergoes an increase in the
process of production: for him, the
question is how great that increase will
be." (16)

In other words, no matter how specific the employment
contract it remains an open-ended agreement, and its details
in terms of work done are finalised only in the day-to-day
interactions between workers and their employer (or the
employer's agents - managers and supervisors). This trans-
lation of "labour power" into "labour" is the managerial
problem of control identified by Braverman, and in the
monopoly capital phase of society's development the solution
takes the form of Taylorism and scientific management.

Taylorism has already been discussed in chapter 2,
but it is worth emphasising what Braverman considers the
most important aspects: labour is reduced from its craft
status to a series of simple tasks (hence the "homogenis-
ation" of the workers); mental and manual labour are separ-
ated (the separation of "conception" and "execution"); and
the "scientific" knowledge of the labour process - now comp-
letely in management hands - is used to plan in detail,
and in advance, the tasks required of each worker. In
appropriating the skill and knowledge involved in production,
control over the nature and pace of work is placed more

directly into management hands, and the advantages for capital are twofold. First, labour is cheapened - an unskilled worker costs less in wages and in training time than a skilled one. Second, and more importantly, the pace and quality of production being in management hands means that managers can more directly dictate the activities of the worker - hence the solution to the problem of the "variable" character of labour power. Taken to its logical conclusion, the application of scientific management provides "the ideal toward which management tends":-

"The subjective factor of the labour process is removed to a place among its inanimate objective factors. To the materials and instruments of production are added a 'labour force', another 'factor of production', and the process is henceforth carried on by management as the sole subjective element." (17)

The precise means of deskilling employed by management can take two forms, first identified by Marx: "In manufacture, the revolution in the mode of production begins with the labour power, in modern industry it begins with the instruments of labour" (18). In other words, capital can achieve its goal either by organisational and disciplinary means (through labour power), or by technological means (through the instruments of labour). Braverman shows how both means are used by managers, and the example of machine tools given by Braverman will serve to illustrate what happens (19). Until recently the skilled machinist remained largely in control of machine shop production. Metal cutting was a craft acquired only by years of experience, and the

employer was dependent on the craftsman's own initiative in producing goods of sufficient quality and quantity to make a profit. In Marxist terms, the employer's capital expended on labour power was extremely variable. Thus in order to wrest control of production and to cheapen labour, management set about breaking down the machinist's tasks among machine operators who would work solely on the lathe, the milling machine, the grinding machine, etc., and machine set-up was made a speciality. Operations could then be determined according to Taylorist standards. However, these organisational means of deskilling met definite limits in the technology, which had to be transformed before further advances in capitalist control could be made. The answer came in the form of numerically controlled (NC) machine tools. With NC, the speeds, feeds, movements, etc., of the machine tool are predetermined in the office by parts programmers who produce a paper or magnetic tape containing "instructions" for the machine from the planning sheets. Machine set-up is now simply a matter of adding the necessary tools, and when the tape is added to the machine's control cabinet the rest is automatic. The machine operator is now left only with the tasks of pressing the on-off switch, and loading the machinery. According to Braverman: "He is now definitively relieved of all the decisions, judgement, and knowledge which Taylor attempted to abstract from him by organisational means" (20). The old skills of the machinist have effectively been transferred to the office.

Thus Braverman's treatment of technology and technical change contrasts sharply with that of the impacts of innovation school, for rather than seeing technology as an exogenous input to productive organisations, it is shown to serve as a functional component in a particular system of domination and control: technology is capitalist technology.

Since Braverman wrote, a number of authors have elaborated his analysis of technology, and applied his arguments in detail to many sectors of the economy. For example Harley Shaiken has examined machine tools in detail, and provides a good deal of empirical evidence (21), and Mike Cooley, a shop steward with Lucas Aerospace, has written extensively on the deskilling effects of new technology both in the office and on the shopfloor (22). A Bravermanesque consideration has recently been given to the application of microelectronics in a range of industries by the Conference of Socialist Economists (23).

Historical accounts of the development of the "capitalist labour process" have also been generated, and Stephen Marglin provides a particularly noteworthy argument when he suggests that the factory system itself was the result of capital's attempt to wrest control of the work process (24). Just as the "impacts of innovation" school assumes that advances in production technology inevitably represent the most efficient means of production, so most would argue that the factory system replaced the previous "putting-out" system because it was a less costly method of production.

However, Marglin argues that by itself the factory system ^{number of skilled} was not technologically superior. Bringing workers together under one roof simply meant that discipline and supervision could be harsher (thus any increase in productivity was explained by a greater input - i.e., labour was forced to increase its effort - and not by any inherent advantage conferred by the factory) and also that "embezzlement" was made very difficult. In sum, what the factory did was to increase profits for the capitalist by extracting more effort and ensuring the gains were fully appropriated. It was only later, when innovations specifically aimed at the factory were developed, that any real technological advantages over alternative systems came about.

There are two points which are particularly weak in Braverman's analysis, but which have been at least partially remedied by more recent work. First, in focussing on the effects of technology at the point of production - i.e., changes within firms - he neglects the effects of wider changes in the economy. In particular, new products and industries may grow up to replace old ones, with whole new sets of skill structures - thus, for instance, the blacksmith and the saddlemaker were virtually eliminated when the motor car came along, and a new set of semi-skilled engineering workers were thrown up: the blacksmith's skills disappeared without recourse to Taylorism. Similarly, some plastic and ceramic components have replaced their metal counterparts, thus affecting the amount and type of work

passing through machine shops and thus the number of skilled machinists employed. Other examples are so obvious that there is no need to list them (25).

Second, although Braverman places a great deal of emphasis on the design of technology, he does not adequately explore the dynamics of the selection and use of design criteria by machine and systems designers. His own argument is that in considering the operating costs of new equipment, engineers will seek a design which enables the operation to be broken down among cheaper operators. Indeed, engineers "...have so internalised this value that it appears to them to have the force of natural law or scientific necessity" (26). In concentrating on this line of argument he fails to emphasise and explain the more overtly political character of technological change. Taking the case of NC machine tools, David Noble has helped remedy this flaw (27). Noble argues that in the initial stages of development there were two types of NC system. One, a "record-play-back" system, allowed the machine operator to make the first of a batch of components in the normal way, using the machine's manual controls. The machine's electronic control system would record the movements, feeds, etc., used by the operator, then the rest of the batch would run automatically. The second, what is now conventional NC equipment, involves the preparation of a paper or magnetic tape by programmers, which is then placed in the machine's control cabinet. This leaves the machine operator the simple tasks of loading and unloading (as explained by Braverman, above). According to

Noble, there were no convincing economic arguments in favour of one control system over the other. Rather, the second type was developed out of considerations of control. That is, in the large firms where NC was first developed and applied, skilled machinists were a problematic presence which management sought to weaken by removing the "intelligence" involved in production from the shopfloor to the office. Thus Noble emphasises how even the conception and design of new technology can be embedded within a particular social and political context.

Critiques of Braverman

Braverman's thorough critique of managerial practice since the turn of the century has been widely applauded, and is already a classic being quoted by virtually all persuasions of students of industry. It is perhaps ironic, then, that his most vociferous opponents are fellow Marxists. They have presented two very basic problems with his analysis - one is his treatment of labour as an unproblematic and totally acquiescent presence in the labour process, and the other, in some ways related, is the presentation of Taylorism as the fundamental practice of twentieth century management.

Taking the first criticism, that workers are not totally compliant to management demands, it has been shown that management attempts to deskill work have been met by organised opposition from labour. Braverman, it is held, tends to lose sight of the fact that there is a "frontier

of control", such that workers can play an active part in shaping their own labour process (28). This often takes the form of unorganised resistance, but on some occasions collective action is more important. For instance it is well known that Taylor himself was opposed by trade unions in the United States. Similarly, skilled workers in the UK engineering industry were able, through collective organisation, to maintain job controls despite attempts to establish new forms of managerial control (29). (The case studies in this thesis could be interpreted as an exploration of worker resistance - albeit largely unorganised - in the engineering industry today.) Instead, Braverman presents the workforce as the passive recipients of a deskilling technology determined by the exigencies of capital accumulation. The domination of labour by capital is presented as virtually complete, and any possibilities for either reform or revolution are treated pessimistically (30).

Related to this criticism, because worker resistance and/or initiatives may qualify management aims and intentions, many have commented on the possibility of alternative management strategies towards the labour process (31). Special reference has been made to the job enlargement and job enrichment programmes which have been increasingly in evidence in the 1970's. Management strategies are held to be variable over time and in different places, and the "humanisation of work" initiatives of late are presented as one refutation of Braverman's universal deskilling hypothesis (32). A group responsibility for enlarged tasks and

for the finished product is held to be used by management in answer to the lack of cooperation of the workforce due to a disaffection from Tayloristic forms of work. Use of this strategy involves handing back some aspects of control over production to workers, but is held to facilitate managerial control in a more important sense: the overall production process remains in the hands of capital, and ownership of the means of production remains unchanged (33).

Related to this criticism, and returning us to the opposition between Braverman and the managerial theorists mentioned in the introduction to this chapter, is the complaint that Braverman's and similar analyses "romanticise" labour - i.e., labour is treated as if it had some universal characteristics which are simply denied under the capitalist labour process. In effect Braverman and his supporters postulate an unchanging human nature which some Marxists cannot come to terms with (34). In doing so, their problem is that some managerial theories and practices are based, at least allegedly, on similar "romantic" conceptions of the nature of man in work. This has implications not only at the epistemological level - for instance, Marx's concept of "species-essence" (35) and Maslow's "needs hierarchy" (36) have much in common - but also at the level of practical recommendation. Thus Braverman's dream of what could be for the machinist if only capital and its deskilling strategy could be overcome, is exactly the same recommendation of at least one managerial theorist - Enid Mumford. Both argue that skilled machinists could, and should, be trained in

programming, so that the whole machining process remains in their hands (37). Little wonder then, that Braverman has to dismiss managerial initiatives as no more than the ideological fig leaves of capitalism. Were they genuine and significant they would force him either to drop the idea that capitalism is the determining influence on technology, or to radically change his notion of capitalism, for in effect Mumford and her colleagues are talking about what Braverman might call a "socialist technology" - where conception and execution are recombined.

In summary, by asserting an inevitable and universal impulsion to deskilling on the part of capital and its agents, Braverman presents a vision of work life which is shaped and determined by the historical development of capitalism. In doing so he loses sight (i) of the way workers can, and do, shape their own relationships both to their fellow workers and to the machinery of production, and (ii) of the degree of choice available to managers in their use of technology. Thus any notion of human choice or agency in technical change disappears behind the logic of an uncontrollable system of capitalism, and in being sceptical of any possibilities of political intervention, Braverman's model tends in its own way to be just as deterministic as that of the innovation school.

Thus while Braverman helps make a nonsense of the idea that technical change is apolitical, he fails to show how the direction of change may be contested - that is, he fails to

show the dynamics of the political processes involved. Instead, he prefers to present change as always and everywhere dominated by the interests of a "capitalist class", with no internal dissension and meeting no serious opposition from other interested parties. The aim of this thesis is to explore the real political processes at work.

CHAPTER FOUR

TECHNICAL CHANGE AND SOCIAL CHOICE

Two Strategies for Management

Marxist critiques of Braverman have made it clear that there is no simple and direct correlation between private ownership of the means of production and the forms of work organisation sought by managers. However, when alternative management strategies are discussed in any detail, they are usually presented simply as different means of capitalist control which are necessary at different times. The ultimate explanation for these strategies is generally the same: the necessity for capital to secure a surplus from labour. Thus the systemic logic of the functionalist Marxist argument is maintained. A good example of the functionalist Marxist argument, since it draws directly from both the "quality of work life" literature of chapter 2 and the "deskilling" thesis outlined in chapter 3, is provided in an important book by Andrew Friedman (1).

Friedman explains the use of "responsible autonomy" strategies and "direct control" strategies in terms of the positions of workers within the labour process. In particular, he identifies a set of "central" workers and a set of "peripheral" workers who are treated differently. Central workers are those considered by management to be essential to secure long-term profits because of their skills and knowledge, or because they are well-organised as a group and likely to use their collective power against



the interests of capital. Peripheral workers are those considered dispensable and easily replaceable, or who present no threat to managerial authority. Central workers not only receive better material benefits and greater security of employment: they are also more likely to be subject to a responsible autonomy strategy - enjoying status, autonomy and responsibility as part of an attempt by management to win them over ideologically to the firm's ideals. Peripheral workers make up what has now become known as the "secondary labour force", being subject to poor wages, insecurity of employment, and, of course, direct control - coercion plus Tayloristic forms of work. They are the powerless of the labour force, often being composed of "culturally disadvantaged" groups such as women and blacks. This centre-periphery dichotomy holds both within firms and between firms - those with greater monopoly power being likely to use the responsible autonomy strategy more often (2).

Thus in this view, management choice is no choice at all. The two alternative strategies outlined by Friedman - responsible autonomy and direct control - are explained away by reference to the exigencies of the labour market. Not being allowed any discretion, management choice is effectively denied, and rational economic explanations found for all their actions. Managers become the mere messengers of an economic system which demands they act in accordance with its logic. Quality of work life issues are thus, in one sense at least, depoliticised by Friedman's

argument, for the responsible autonomy strategy is treated simply as an alternative means to the same end, made necessary in certain circumstances beyond management's control (3). However, Friedman does recognise two ways in which the responsible autonomy strategy can come about:

"....top managers may loosen direct control over work activity as part of a strategy for maintaining or augmenting managerial control over productive activity as a whole (....), or they may be forced to loosen direct control as part of a general shift in control over productive activity in favour of the workers." (4)

The "general shift in control", Friedman argues, can be brought about by organised worker initiatives, and these are "progressive" from the workers' point of view.

Other authors, being a little more pragmatic, have pointed out that management-initiated changes can be beneficial to the workforce so long as workers and their representatives maintain an involvement in job redesign. Josep Bolweg and Daryl Hull both take up this line of argument (5).

The Values of Engineers and Managers

In opposition to the functionalist accounts of orthodox Marxism, another way of looking at management strategies is to focus on the values of those responsible for the design of jobs. A study of this type was carried out as early as 1955 when Louis Davis and his associates examined the job design criteria used by relevant managers and engineers in a range of firms (see chapter 2). This work

has been followed up recently by Bo Hedberg and Enid Mumford in their study of the design of new computer systems (6). Using McGreggor's "Theory X" and "Theory Y" views of man (see chapter 2), Hedberg and Mumford compared the values of British and Swedish systems designers. British designers were found generally to be more Theory X oriented than their Swedish counterparts, and this, the authors claim, is reflected in the design of more centralised systems allowing less discretion on the part of office staff and other users of the computer (7). This type of analysis is normally accompanied by an examination of the social background, or "culture", of designers in order to explain their values and philosophy, and education and training become particularly important areas (8).

Connected to these explanations is the view that the values implicit in science and technology themselves have implications for the design of work. In particular the values of precise measurement and control of the environment are the ones at the forefront of the minds of engineers and managers when designing technical systems. They may thus feel a need to apply these values to man, too, and Lisl Klein even suggests an anxiety on the part of designers towards the less quantifiable aspects of human behaviour (9). The result is the design of technical systems which attempt to turn man himself into a machine - another measurable and quantifiable entity.

However, important though the education and training of engineers undoubtedly is, Hedberg and Mumford do not

claim that this is the sole problem. In fact, their study also revealed that even though all the systems designers interviewed tended more towards a Theory Y than a Theory X view at an "intellectual and theoretical level" (the Swedish ones more than the British), at an "operational level" Theory X views were more dominant. That is, in terms of the criteria for design actually operationalised by designers, a pessimistic view of man was in evidence more often. In an attempt to explain this occurrence Hedberg and Mumford make reference to the powerlessness often expressed by designers, and the possible conflict between their own values and their responsibility to superordinates (i.e., top management) to produce a design to their liking. Further, Lisl Klein points out how the orientations of other organisational members may be taken into account (10), and of course, financial, technical and time constraints may limit the possibilities for a more humane technology.

In sum, although the values of engineers (and others) involved in job design may influence the design of technology, the interests and values of other parties will be taken into account, and the specific context of change will have a bearing on resulting designs.

Strategic Choice

Our intention is to steer a course between the overdeterministic view of Friedman on the one hand, and the extreme voluntarism which becomes a danger in adopting a "models of man" view on the other. In not wishing to dismiss

either of the two views as absurd, we should recognise that: (i) man is never totally determined by any particular system - capitalism just like any other allows enormous room for manoeuvre, and that (ii) talking about choices apart from a historically specific context is meaningless.

Friedman is right in pointing out that changes take place within specific contexts. Managers and engineers cannot simply instigate the job designs which are most in line with their values, for as Bryn Jones has made clear, the product and labour markets within which the firm operates, the tradition and strategy of relevant trade unions, and the views of other managers within the firm, play vital roles in shaping work organisation (11). However, these contextual factors still allow room for redirection of the firm's organisation, and besides, the contextual variables which help determine change are themselves subject to choice by managers and others, and are thus in part reflections of the values of the various interest groups involved - for instance, an economistic trade union may be a reflection of the instrumental values of the workers.

A general approach to organisational change which takes account of these facts is presented by Child with his concept of "strategic choice" (12). Child urges us to "....consider the process of choice....in which economic and administrative exigencies are weighed by the actors concerned against the opportunities to operate a structure of their own and/or other organisational members' preferences" (13). The "systemic exigencies" which supposedly

determine organisational structure can now be seen as references used by organisational members who hold particular assumptions and values, and thus both the pragmatic and moral dimensions of decisions can be taken into account.

In relation specifically to technology, the immediate objection to this type of view is likely to be that as long as firms are in competition, the "one best way" of producing goods (or services) will inevitably come to dominate as its advantages make themselves felt. That is, the contextual variable of competition will in the end always be deterministic. However, there are at least three reasons to be sceptical of this claim. First, "productivity" or "efficiency" cannot be accurately measured. Second, the total acquiescence of labour can never be assured. Finally, even if it could be measured and imposed, there is always more than one "best way" of designing and using technology. This is not to deny totally the importance of competitive and efficiency considerations, but it is to deny their role as sole determinants. Our case studies display how efficiency and productivity may in fact be secondary considerations, or at the most, constraints on possible options. We will present a lengthy discussion of the precise role of efficiency in the light of the empirical findings in chapter 13.

Managers and engineers, then, instead of being seen as the intermediaries - the messengers - of a technical and economic system which demands they act in accordance with its inherent logic, can now be seen as political beings

with particular interests and in particular positions of power. They become the creative mediators between potential and actual technology. They become, in fact, responsible for their actions.

Technology as Outcome

If there are real choices to be made with regard to technology, then technology must be, at least in principle, a negotiable phenomenon. Various groups within organisations will attempt to impose their own interests on the design and use of technology. As Pfeffer points out:

"...if technology is chosen, and chosen using considerations of control as well as efficiency, then it is likely that technology can best be viewed as an outcome, rather than a cause, of fundamental organisational processes. The choice of technology and the organisational design both reflect and affect the distribution of control in the organisation. Each is caused by the contest for control in the organisation, and the resources that are brought to bear in that contest." (14)

There is still a nagging doubt, however, because technology, like science, is surely somehow autonomous? - i.e., neutral and value-free, devoid of politics? But the objectivity of science itself has recently been challenged, and this includes not only the "soft" targets of applied social science (cost-benefit analysis, cybernetics, systems analysis, etc.), but also the "higher" sciences of physics, chemistry and even mathematics (15). This is not the place to discuss the sociology of scientific knowledge - suffice it to say that the claim that science is objective and there-

fore divorced from politics is becoming weaker and weaker. As yet there is, unfortunately, no sociology of technical knowledge, but our arguments so far have made it clear that technology is politically informed. In particular, production technology and its associated working practices can only be understood by reference to the social actors involved in its design and use. As Seymour Melman summarises: "...the shaping of the means of production may be understood as the derived effect of the application of socially preferred design criteria to the properties of materials given by nature" (16).

Of course, as our case studies will show, many or most people generally continue to see technology as largely objective and unchallengeable, but this may act only to serve the interests of the beneficiaries of technology - it can act as an ideology. In particular, managers may use such arguments simply in order to preserve their prerogative in this area of decision making, thus obscuring the real issues of control involved.

Before going any further in our analysis, the question we must answer is "how do the politics of change work?" Empirical documentation of the dynamics of change is negligible, with most studies taking for granted or ignoring exactly the processes we wish to explore. The case studies which follow, then, will examine how managers, workers, engineers and others actively participate in technical change. They will show how these interested parties influence the direction the social and technical organisation

of work takes, thus providing an important corrective to deterministic models of change, but without regressing into an analysis of the psychology of managers and engineers.

So far, however, we have given little indication of the character of automation in batch engineering - the sector we have chosen to illustrate our arguments - and thus chapter 5 will provide the technical and economic background to the case studies.

CHAPTER FIVE

MICROELECTRONICS AND MANUFACTURING INDUSTRY

Automation and the Microelectronics Revolution

There has been a debate on "automation" and its impacts for many years now, with particular attention arising with the computer in the 1950's. Recently, with the rise of semiconductor electronics, the debate has been sparked off again, with a host of commentators predicting and forecasting all sorts of impacts on working lives, on leisure patterns, and so on. Of course, it is not possible to do justice to all the research in these areas in so short a space, and the next few pages present only the briefest of summaries.

What microelectronics has done is, first, to decrease both the physical size and the economic costs of electronic devices - including computers - and, second, to extend the range of processes which are amenable to automation. Applications are now found in virtually every sector of the economy, and costs have reduced so dramatically that for many applications they are no longer inhibiting to even the smallest firms (1). Many commentators are thus hailing a revolution in industry and commerce which is likely to have repercussions equal in magnitude to the industrial revolution itself.

At a "macro" level, the two main issues are first, the likely impact on overall employment levels, and second, the rise and decline in the relative importance of the various

sectors of the economy as sources of employment. Predictions of future levels of unemployment caused by the displacement effects of the new technology vary enormously, and the measurement of these effects is fraught with difficulties. However, there is general agreement that any unemployment caused by microelectronics will in the long term be less serious than that which might be caused by the failure to automate, because of the enormous competitive advantages which are at stake. In short, as long as British industry competes with that of other countries, it must make use of the chip or face the chop (2). The problem is then, how best to ensure the even distribution of the benefits of the new technology, and issues such as possibilities for work sharing or for shortening the working week must be raised. Traditional ideas about unemployment must be brought into question, and indeed so must the whole work ethic which has dominated the Western world for the last few centuries.

Associated with the debate on the effect on overall employment levels is that on the rise and decline of economic sectors. Manufacturing industry has required less and less labour for decades due to advances in production technology, but so far the surplus labour created has been taken up by growth in total manufacturing output and by new and growing service industries - health, education, finance, insurance, recreation, etc. Here the services are held to be needed to expand even further to absorb the displaced labour associated with microelectronics, though it is questionable whether or not this will occur (3).

Also there is a debate on the changing character of the labour force brought about by the rise of the service economy. This has already been discussed in chapter 2, but to summarise briefly, the main issue of the debate is whether the growing service economy represents - as Daniel Bell suggests - a radical divergence from traditional industry, or whether it is in fact mainly an extension of the existing order - as is argued by Jonathan Gershuny. That is, are the new services socially-oriented - as with medicine and education - or are they, like banking and insurance, aids to the efficiency of material production? One of the latest contributions to the debate comes from Clive Jenkins and Barrie Sherman, who urge the development of a "pink-collar" sector to absorb displaced labour. "Pink-collar" work is in the "person-to-person" services such as hairdressing, entertainment, restaurants, and so on, and generally not being amenable to automation (unlike many other services), could bring many employment opportunities (4).

Our own interests in the microelectronics revolution are in the more detailed qualitative aspects of employment, and this chapter will focus on the implications of change at the level of the office and factory floors (5).

Applications in Manufacturing Industry

For the general employment issues mentioned above it is difficult not to talk about the effects of microelectronics as a whole, and, no doubt, for some purposes this

may be highly desirable. However, discussion of the qualitative employment aspects of applications at the point of production can easily lead to confusion if the type of automation is not distinguished, and this is probably one of the main reasons why authors such as Blauner and Bright could come to virtually opposite conclusions (see chapter 1) - they use exemplars from different industries. At the very least, we might distinguish between "continuous process production" (oil refineries, chemicals, etc.), "batch production", "mass production" and "office automation". Different "impacts" have been recorded in each of these sectors (6). Our case studies are mainly of batch production in various sectors of the engineering industry, and the specific character of automation of this type of manufacturing process will now be discussed.

Until the advent of sophisticated electronics and computers after the second world war, automation could generally be described as "hard" automation, where making processes automatic involved the use of stops and cams and so on, so that human intervention was not required. This type of machinery has its origins at the latest in the nineteenth century, and it continues to be important today. Its use is limited, however, to mass and large batch production, since once set up, it is normally a very costly and time-consuming business to adapt the machinery to even slight changes in the product. Indeed, product changes may even mean the scrapping of whole sets of machinery which are no

use for any other purpose. Thus many sectors of the engineering industry, where small and medium sized batches predominate, have found little use for these conventional automatic machines, and by far the majority of batch production processes remain manually controlled.

Today, however, automation of batch production is on the increase, and automation even for very small batches or one-offs (single components) is becoming economically viable. This is because of the advent of electronic and computer-controlled machinery, where control of the production of a component lies not in the physical hardware of stops and cams, nor in the form of the human machine operator, but rather in the programmable software of the machine's electronic control system. Here we might refer to "soft" automation. The use of soft automation for small batches is made possible by the flexibility which comes with programmable control - reprogramming or resetting is easy compared with adapting hardware. The increasing sophistication and decreasing costs of electronic control systems due to the availability of microelectronics has enormously extended the range of feasible applications, and virtually every sector of manufacturing industry which uses multi-purpose machinery is either presently under competitive pressure, or likely soon to come under pressure to make use of the new control devices.

Soft automation arose after world war two, the first applications coming in the form of numerically controlled (NC) machine tools in the metal working industry. Electronic

control devices are, however, equally applicable to other, similar, multi-purpose machinery, and as well as machine tools, the applications observed in the case studies included die-casting machinery, plating equipment, mechanical handling equipment, a press, and rubber moulding machinery. Partly because of the vast numbers of machine tools in use, attention has been focussed on automation here rather than on any other machinery, and our discussion will thus focus on numerical control as a detailed exemplar of soft automation for batch production. It should therefore be borne in mind that very similar issues are raised by electronic control devices applied to the whole range of machinery mentioned above.

Electronic Process Controls - the Example of NC

The development and application of numerical control for machine tools began in the late 1940's and early 1950's, and with the increasing sophistication of electronics in the 1960's began to spread rapidly throughout the engineering industry. The aircraft industry was the first major user, but NC usage has now spread to all sectors. The NC market in the UK has grown by around 9% per annum since 1971, and existing NC machinery in 1978 represented about 1.5% of all machine tools (7). It is expected that cheap microprocessors will lead to a more rapid increase in market share in the near future (8). The UK has been slow to take up NC, and the reasons why have been discussed in detail (9).

Basically, with NC information on the size and shape

of a component is fed into a control device - the information bearer normally being a paper or magnetic tape. This information is then passed via a series of electro-mechanical devices (the machine's "servo-mechanism") which can run the machine. The technical advantages of this system over conventional (manual and automatic) control systems can be many and varied. Most importantly: pre-coding of the job means that metal cutting is made easier and that the tool itself can be in more constant use; the tape can be filed and recalled whenever needed, and minor design modifications can easily be made; and compared with conventional automatic machine tools flexibility is greatly increased. The cost per standard hour of the new machine is higher than that of conventional machines due to higher depreciation (NC is more expensive) and higher support costs (especially maintenance and programming), but these costs can be offset by higher output, and thus decreased cost per component, if utilisation is kept high (10).

More recently "computer numerical control" (CNC) has been developed, where a computer is installed on the machine tool itself. With this system the programme is read only once for a whole batch of components, the programme being stored in the computer on the machine. It also means tapes can be edited at the machine itself, reducing total tape preparation time and thus increasing utilisation (11). Going one stage further, CNC has facilitated the development of "DNC" (direct numerical control) systems, where several machine tools are controlled simultaneously by one central

computer. However, while CNC has now virtually replaced NC, DNC is still mainly in the experimental phase, and the cost of these systems is likely to remain prohibitive for the vast majority of engineering concerns for some time to come.

NC machinery, like other types of automation, takes control of processes - literally - out of the hands of the workers who have traditionally operated them. Rather than being controlled during production proper, the movements of the machinery are now pre-set, and the skills involved in machine control are effectively "transferred" to the function of programming.

Programming for NC involves the recording of the specifications of engineering drawings on planning sheets, and their conversion into "machine-readable" form. At the same time the speeds, feeds, cutting tools required, etc., are also converted. The full programme, normally in the form of a paper or magnetic tape, is then installed in the control panel. Tool setting is done as before, except that decisions on which tools to use are already provided on the programme sheet. Switched on, the rest is fully automatic.

With conventional NC, any errors in the tape would mean its return to the programming office for modification, and this could mean its travelling to and from the office and the shopfloor several times before production properly got under way. With CNC, however, tapes can be proved at the machine itself - any necessary modifications being made with the first of a batch. The machine's computer auto-

matically stores any modifications in its memory, and at the end of the batch the new, modified, programme can be recorded at the machine on a fresh paper or magnetic tape. With some of the very latest CNC systems, the machine's computer memory is in fact powerful enough to record hundreds of programmes, eliminating any need for tape storage (12).

With machine tools the control systems are generally introduced as a part of new machinery - the machine supplier doing the "adding-on". However, with other applications it is occasionally the case that a new computer control may be added on to existing machinery within the adopting firm, and there are no technical reasons why this method of innovation should not be attempted more often, particularly where firms use highly specialised processes and machinery suppliers are rare.

Other Applications of Microelectronics in Batch Production

At the same time as machinery on the shopfloor is automated, automatic devices to aid the design and drawing of engineering parts are being introduced in some offices. Working CAD (computer aided design) systems are currently extremely rare in batch production, but again microelectronics, in making them cheaper and more powerful, may make them viable in many engineering firms in the near future. In translating the numerical calculations of designers into actual engineering drawings - either on paper or on visual display units - the traditional role of the draughtsman is

likely to be radically changed. It is also possible that programme tapes for production may be produced direct from the same CAD facilities, though viable systems for small batch production are yet to be designed (13).

Computerised production control is also being introduced into some batch production concerns, but again there are more difficulties than with, say, mass or process production. This is because many engineering shops have an enormous number of small batches of components passing between the various machining functions at any one time. In most shops today the old manual production control methods which rely on the detailed knowledge of the progress chaser still predominate, but attempts are occasionally being made at computerisation. Our case study of a machine tool manufacturer provides one such instance, and a discussion of both the technical and the social aspects will be found there (14).

Effects of Automation in Batch Production - the Debate So Far

J.Remmerswaal has forecasted that the total effects of the technical changes described above will be an increase in productivity of 200-300% by the mid-1990's, and unless demand doubles or trebles (which is highly unlikely) this will mean an employment reduction of 50% within 15 years (15). Of course, one must remain highly sceptical of such extravagant claims, though some employment reduction will be inevitable. Claims of productivity improvements for individual NC machines vary enormously, and much depends

on the utilisation achieved. To date in the UK it is probable that most labour immediately displaced has been absorbed elsewhere within adopting firms - and certainly this has happened in most of our case studies. However, this depends on the expansion - or at least the maintenance - of the firm's market, and displacement effects caused by productivity improvements may only make themselves felt with a change in the economic climate. Thus some of the redundancies being made by our case study firms during the present recession are no doubt due to changes in technology two or three years ago. In this way displacement effects are masked by changes in the fortunes of the firms in the market place, and measurement is made extremely difficult. There can be no doubt, however, that the general employment reduction trend in the UK engineering industry owes less to automation than to the failure of firms to invest in R&D and new production facilities (16).

The striving for higher utilisation with automated engineering machinery means that many firms introduce shift-work and/or increase overtime. Twenty four hour exploitation of machinery has, of course, been common in many factories for many years, but automation may help increase this trend. Further, white collar workers such as maintenance technicians and programmers are likely to be drawn into the shift system (17). However, unlike oil refineries and the like where the whole plant is automated and demands twenty four hour operation to be economically viable (and in some cases to be technically feasible), the automation of single multi-

purpose machines can be undertaken gradually (i.e., one at a time). It may not be feasible to introduce shifts for, say, two or three machines, and there is thus no simple relation between technical developments and shift patterns.

Our central concern is with the changing composition of the labour force associated with the new technology, and here exact relationships are even more difficult to establish than with labour displacement or shiftwork patterns. However, it is generally commented on that the electronic devices mean a reduction in demand for motor skills, and an increase in demand for conceptual skills. The machine operator thus loses his traditional role as skilled or semi-skilled worker, and becomes a machine minder, intervening only when the machine goes wrong, while the new occupation of programmer (or "process controller", depending on the type of machinery in question) arises, demanding a whole new set of conceptual skills. At the same time, the new maintenance requirements associated with automation, and in particular with microelectronics, means that new skills and combinations of skills are required from maintenance personnel.

Probably the best description of job changes associated with the automation of batch production is that by Erik Christensen (18), although this work is now dated. More recent empirical findings are provided by Swords-Isherwood and Senker (19). (Both studies describe NC technology, but as Christensen himself points out, control systems for other types of batch engineering are very similar.) What both

these descriptions have in common is a general failure to establish any clear-cut patterns of work organisation associated with NC technology. Instead they have to go into some detail on variations established in different factories, both in terms of precise details of design of control systems, and in terms of working arrangements established with given control systems.

Particularly important is the different divisions of labour which were found in different plants, with the demarcation between operator and programmer tasks being blurred, and occasionally the operator even carrying out some programming himself. Similarly the division of tasks between planners and programmers varies - the programmers occasionally by-passing the planners by working straight from engineering drawings. Another variation found was in the setting of the machine's tools. In most cases skilled or semi-skilled machine operators set their own machines, but occasionally a skilled machinist would be responsible for the setting of a group of machines, while unskilled operators simply loaded and unloaded one or more machines.

On the design of control systems, Christensen points out three types - two conventional, and one called "play-back control", where a skilled operator makes the first of a batch of components while the movements of the machine are recorded on a magnetic drum or punched tape. Play-back control eliminates the need for a special occupation of programmer, and virtually the only significant difference in operation between this system and a conventional machine

tool is the simple fact that the operator is not required to repeat the same movements over and over again for the whole batch of components (20). Writing later, since the advent of more sophisticated microprocessor-based control systems, Swords-Isherwood and Senker are faced with even more differences in detailed design, and the degree of operator intervention in programming is likely to be different in each case.

In both studies the "innovation" approach referred to in chapter 3 is dominant - changes in work organisation are presented as the more or less direct result of advances in technology, which, upon their diffusion, are having "impacts". The variations in organisation from plant to plant are dealt with, accordingly, in terms of the specific set of technical and economic circumstances in each location. Thus Swords-Isherwood and Senker point out that batch size, complexity of components, the existing inspection system, the training and experience of supervisors, the technical abilities of programmers, etc., all affect the way work is organised. For example: a rigorous inspection system means less operator decisions; large batches and low complexity of components may make the use of unskilled machine minders desirable; and a totally incompetent programming staff may mean skilled operators have to provide them with a good deal of advice.

However, an indication of the inadequacy of this analysis is provided by the authors themselves, when they comment - albeit ambiguously - that with some new control

systems managers have the scope "...to build in more opportunities for shopfloor intervention to improve performance. Managements may be reluctant to take advantage of this because it would lessen their opportunities for controlling output" (21). This could be taken to mean that management control of output will in the long-run secure a higher performance. But it is also a suggestion that issues of control are inextricably bound up with technical change, and also that managers have choices to make. The case studies in this thesis are an exploration of exactly these issues, and represent an attempt to uncover the social and political processes which are obscured by previous analyses.

As chapters 3 and 4 concluded through a theoretical discussion, the technical and social organisation of work can best be seen as an outcome which has been chosen and negotiated. Thus explanations for the variations in work organisation uncovered by the empirical studies above need not be constantly sought in detailed technical and economic circumstances - important though they may be. Rather, choices in technology and the ways in which it is used can be shown to have a political dimension, derived, as Pfeffer puts it, from the "contest for control" in the organisation (22). In this view, the design and choice of technology may be seen as the result of socially-derived decisions, and the way in which technology is used can be explained in terms of the political processes - formal and informal - of negotiation, persuasion, bargaining, and so on.

CHAPTER SIX

AIMS AND METHODS OF RESEARCH

The Research Setting

Being located in the heart of Britain's "manufacturing base", the University of Aston provided the ideal site from which to conduct empirical research into batch engineering. As a region, the West Midlands consists of the six counties of Herefordshire, Worcestershire, Warwickshire, Staffordshire and Shropshire, and the new county of "West Midlands". Most of the case studies undertaken were within the West Midlands county itself, which stretches from Coventry in the east to Wolverhampton and Dudley in the west, and of these, nearly all were within that great urban blot on the map which constitutes Birmingham and the black country (1).

The West Midlands is characterised by a high concentration of employment in metal-processing, and with ship-building absent and the heavier industries less in evidence, it represents one of the most specialised industrial regions in Britain. One of the major reasons for the region's specialisation is the motor vehicle industry, which demands a host of component-producing firms to provide the materials necessary for assembly. Motor vehicle assembly was not included in the case studies, but provided the largest single market for the firms studied (2).

However, as we shall see below, the original set of twenty seven case studies, for the purpose of this thesis, served largely as a pilot study to the four more detailed

case studies presented. As our focus narrowed to a few specific plants the regional flavour of the project declined, and although they are still exemplars of technical change in the West Midlands, the regional context is relatively unimportant. Thus claims for their typicality cannot be made. More important is the fact that all the case studies are examples of innovations based on microelectronics in batch engineering, and chapter 5, accordingly, outlined the specific character of automation in this sector. The case study of events in a machine shop - one of our four major case studies, and by far the most detailed one of those four, taking up two chapters - presents many events which will be familiar to students of the social aspects of technology, since previous empirical research has been heavily biased towards machine tools. Our other three case studies, however, are from firms in other sections of batch engineering which are relatively unexplored, and although this is not a primary justification for the research, any empirical examination of technical change in these sectors is likely to be valuable.

Research Problems

Chapters 4 and 5 concluded that previous research had failed to uncover - or even served to conceal - the political aspects of technical change. The tendency was to treat changes largely in technical and economic terms, and to present any social aspects as dependent variables. Empirical documentation of technical change thus failed to explore

the roles of engineers, managers, and workers, except to the extent that they presented "barriers" or "obstacles" to innovation, or to the extent that they were changed themselves by the innovation (the "impacts" of innovation). Where research has examined the social forces behind technical change it has tended to explain innovations and their consequences by reference to a social system (normally capitalism) which determines the way technology develops and is used without reference to any possibilities for choice in technology and work organisation, or to the negotiation of changes.

In sum, previous research has failed to map out the politics of change - the processes of bargaining, negotiation, accommodation, and so on, which we can expect to occur when new technology is chosen and implemented. The major questions which need to be explored are the following:-

- i) What are the interests and values of those actors or interest groups who are implicated in the technical change (engineers, managers, workers, etc.)?
- ii) How do they perceive the change and what do they expect to gain or lose from it? Do they intend to impose their own interests during the change, and if so, how?
- iii) Does the technology act, or is it perceived to act, as a determinant of, or constraint upon, the form of work organisation which evolves?
- iv) How, and through what mechanisms, is technology chosen? How, and through what mechanisms, is

the work organisation negotiated? Is collective bargaining or other types of formal negotiation important? Or is the informal negotiation of working practices more important?

The exploration of these processes requires the use of intensive observational methods through case studies. Only in this way can one seriously hope to uncover the political - i.e., contested - aspects of change. The specific methods used will now be discussed.

Research Methods

The primary methods of research were:-

- i) Interviews with the various interested parties.
- ii) Observation of working methods and practices; and discussion of these methods on the job with managers and workers.
- iii) Examination of documented information.
- iv) Observation of meetings relevant to the choice and negotiation of change.

There was no clear and obvious preference for any of these methods of data acquisition over the others, and the original intention was to use all the methods to the fullest extent. Of course, this was not possible in all cases for various reasons, and whatever sources of information were made available were considered. Occasionally information gained on important points was suspect, or could not be verified, or was too vague to be useful, and these difficulties are presented in the case studies.

For the most part, once initial access was established (the general problem of access is discussed below), the case studies involved arriving at the firm in order to conduct a pre-arranged interview with a senior manager, and later attempting to persuade the manager to allow interviews to be conducted with other managers and workers within the organisation. In some cases the confidence of one or more managers was gained, and the gathering of information spread from there into the lower echelons of the organisation. Specific problems of access to certain sources of information were met as they came along. As in all social research, data was in certain ways incomplete, but in the four detailed case studies it was felt that a reliable and adequate data base was established (3).

Since the case studies were longitudinal - i.e., they covered events over a period of time rather than present "snapshots" of the organisation - revisits were necessary over long periods. Unfortunately, the period of research was generally too short to cover all the various stages of innovations from design to trial to implementation to debugging and so on, and thus post hoc accounts of events were occasionally relied upon. Similarly, in at least one case (the rubber moulding firm) the research had to end before the "story" was complete. Without extending a research project over at least several years, little can be done about this problem of time-scale. However, these problems are more than compensated for by the detail which this type of work allows, and besides, the implementation and debugging

phases - our major concern - were generally well covered in the research.

Interviews were the major source of data, and occasional discretionary use was made of a tape recorder. Questions to be put to interviewees were generally construed prior to the interview, but interviews were mainly open-ended in an attempt to record the views and perceptions of the respondents. Familiarity with some of the actors involved, especially in the case study of the machine tool manufacturer, meant that eventually conversations came to replace formal "interviews", and the research could almost have been described as "participant" observation.

Initial interviews with senior managers were used to establish the background of the company - size, product market, management structure, and so on - and also to gain an account of relevant technical changes from their perspective. Interviews and meetings with other relevant actors would then focus on specific aspects of the innovations as they related to the actors' own perceived interests. In this way the important events within firms came to light, and specific features of innovations could then be followed up in detail with the various interested parties.

Observing the working methods used by the various sections of the workforces was often the easiest way of coming to terms with the specific implications of technical change. Most people are in any case starved of opportunities to discuss their work, and a serious listener was in most instances welcomed. Apart from recording details of methods,

it was also possible to gain insights into workers' views of technical change, and the specific preferences for working practices which they had.

Documented information was often difficult to acquire, and managers would normally wish to vet the information which they were willing to pass on. The two most valuable types used were (i) formal justifications for expenditure on capital equipment, and (ii) written agreements on manning levels, work practices and payment systems associated with new technology. Use of both these sources of information, however, was problematic.

Finally, observing relevant meetings was rarely allowed, and provided no important data even though its potential to do so appeared great.

Methodological Problems

Taking the use of documented information first, formal written justifications for expenditure on capital equipment tended to be highly technical, and gave the impression that choice of technology was of interest only to production engineers. The final decision or recommendation was virtually always in terms of the technology's economic advantages - payback periods, etc. Yet interviews even with the engineers responsible for writing justifications almost invariably revealed some social and political dimensions to the decision. The written justification then, was in part a "scientific gloss" which might crumble when examined at all closely. Their use as empirical evidence of the motivations

behind changes, without the support of solid observational and interview material, is likely at the best to be inaccurate, and at the worst misleading (4).

Similarly, formal written agreements on aspects of new technology were of little use by themselves. These were in any case rare, and where they did exist they normally concentrated on issues of pay and redundancy. Where working practices were specified, there were normally important divergences from the written agreement. Only by examining the day-to-day interactions of workers and managers could working practices be properly understood. Apart from this necessary incompleteness of formal agreements on working practices, they also fail, of course, to give any indication of either the motives of the various interest groups in attempting to achieve particular forms of work organisation, or the power positions of these groups. Thus in general, most of the qualitative information required was not on record, and where it was it could be used only in the context of more reliable interview and observational evidence.

Observing relevant meetings was rarely allowed by managers, and for the most part second hand accounts had to suffice. Since most formal worker-management meetings on new technology concentrated, in any case, on pay and redundancy (normally slightly increased pay grades and guarantees of no redundancy) this was no great loss. However, meetings between managers themselves, where issues of supervision and control were discussed, could have provided invaluable sources of data. Occasionally informal "meetings"

developed in my presence during the machine tool manufacture case study - especially between superintendents and foremen - and these more than any other source clarified for me the various interests and power positions of different groups of managers. But it was not possible to observe the same in the higher reaches of management. This was a part of the more general problem of access to people in positions of power - what Colin Bell has called the problem of "studying up" (5) - and represents one of the major limitations of the case study approach. There is no simple answer to this problem, but in retrospect it might be said that I could have displayed more confidence, and certainly the advice to anyone else contemplating intensive methods where senior managers are involved is to take this problem seriously into account - perhaps enlisting the practical support of more senior academics (6).

The Case Studies

Before the more detailed case studies were undertaken, twenty seven firms had been visited and at least one manager interviewed from each. These case studies were the basis of a general examination of manufacturing innovation in the West Midlands undertaken by Professor Ernest Braun, Dr. Russell Moseley and myself, and the results will shortly be published (7). Some aspects of work organisation from these studies have been related in this thesis in chapter 7, and they provide a background for, and an introduction to, the more detailed case studies.

It may, however, have been more appropriate - if stylistically unacceptable - to locate the discussion of these twenty seven cases before this chapter on methods of research, since they were an invaluable preliminary to the more detailed studies in two important senses. First, they helped the formulation of research problems, and second, they eliminated the problem of access. Thus in some senses they were used as a pilot study.

Of the twenty seven firms, about a dozen provided good examples of microelectronic applications to manufacturing production processes, and from these, several firms considered suitable for more detailed investigation were chosen. The firms selected were all engaged in batch production (8), and all provided the opportunity to study microelectronic control devices. Although dissimilar in products and markets, their manufacturing processes were similar enough to make comparisons relevant to the concerns of this study. It was important that each firm provided the opportunity to study the various stages of innovation, and it was necessary that the firms offered access to sufficient individuals or groups of people within the organisation to make examination of political processes feasible.

The twenty seven cases covered the whole range of sizes of firm - in fact from less than ten to several thousands. The detailed case studies are of two small firms with around 50 employees each and two medium sized firms with several hundred. Three of these four firms were parts of larger groups, but nonetheless their relatively

small size was a notable aspect of the study, since smaller firms are relatively unexplored.

Finally, three notes on style of presentation should be made. Firstly, although written soberly and dryly, the case studies are presented as unfolding "dramas", as in telling a story. The organisation of the empirical material gathered need not have taken this form, but it is hopefully a good way of making a mass of tape recordings and notes intelligible, at the same time as making it interesting and readable. It should also provide a sense of change and development over time in organisations, rather than give a picture which is static and apparently inevitable. If the reader occasionally sympathises with certain actors or groups, this is all to the good: we are, after all, discussing political events.

Secondly, after some deliberation, it was decided to standardise the English used in quotations from tape recordings. This was not only because a black country dialect is difficult to write down, but also it could divert attention from some very serious points which were being made.

Thirdly, all firms and actors are presented anonymously for the usual reasons. This is particularly important in a study of this type since some evidence was recorded in confidence. Fortunately, the firms are small enough to make their identification virtually impossible, and thus details have not had to be changed.

SECTION TWO
EMPIRICAL FINDINGS

CHAPTER SEVEN
THE PILOT STUDIES

Technical Change and Reorganisation

Of the original twenty seven firms visited (1) around twelve had recently applied, or were in the process of applying, electronic devices for the control of their manufacturing processes. This includes four firms who were using NC and/or CNC machine tools, but also other firms who were using sophisticated electronics to control a large range of other manufacturing processes - e.g., electronic controls applied to plating equipment, a forge, die-casting machinery, and rubber moulding machinery. The list of possible applications within engineering, it seems, is endless. This chapter will present briefly the work organisations which had evolved in these firms with regard to this type of new technology.

Only in two cases were the control devices "added on" within the manufacturing firms. For the rest, the devices came as a part of new machinery. But what all the applications share in common is that in making manufacturing processes automatic, they are taking control of the quantity and quality of production out of the hands (literally) of the workers who operate the machinery. Rather than being controlled during production proper, the movements of the manufacturing machinery are now pre-set, and the "operator", if needed at all, is really reduced to the level of a machine minder. This does not necessarily mean that the operator

becomes redundant or deskilled. Rather, the skills involved are "transferred" to the pre-setting function, which often means programming, and someone has to carry out this new task. But it does mean that manual control of the machine's movements, and thus our conventional idea of "operator", is eliminated. Of course, as chapter 5 pointed out, with many large batch engineering processes, this has in many cases already been achieved through conventional automatic machinery. For example, automatic machine tools are set by the toolsetter (often a specialised task) then the rest is automatic - no one has to control the machine's movements by hand. But for small and medium batch processes, conventional automatic machinery is too inflexible. Electronic controls overcome this inflexibility problem, at the same time as making the production of components faster and more reliable, and often making complex parts both more accurate and more repeatable.

But apart from these more obvious technical advantages, the new technology offers managements the opportunity to reorganise the workforce along new lines. As we shall see, the payment system, shiftworking patterns, manning levels, and in particular the tasks which workers will carry out, are not determined by the hardware, but they do have to change. For instance, as described above, process control devices mean that machine operating is a redundant task, and the work of the operator must thus be redefined; manning levels may be brought into question; the payment system may have to change in accordance; and shiftwork may be

envisaged as a way of justifying the capital expenditure involved.

Even given the apparent similarity of many of the applications, no clear pattern of work organisation emerged. Rather, a range of organisational intentions and designs were apparent.

Machining (2)

Out of about fourteen firms using machine tools on a significant scale, only four currently utilised NC or CNC. A different approach to dividing the tasks characteristic of this technology was evident in each. At one extreme the tasks of the machine operators were reduced largely to loading and unloading the machinery, and to monitoring the process. Programming for the half dozen machines was carried out by the managers alone, and this strict task division was justified on the grounds of the complexity of programming (components being produced were highly complex parts for the aerospace industry). The managers claimed they recognised the boredom involved in machine minding, and hoped that future CNC machines, by making programming a simpler task, would facilitate operator programming (3). In a second case the CNC operators were previously skilled workers familiar with conventional machinery. Here one or two were becoming involved in programming, but the owner-manager of this small machine shop, perceiving a shortage of skilled labour in the market, talked of using his skilled "nucleus" in the toolroom on conventional machines, and

recruiting unskilled labour to "mind" the expanding CNC section. In his words, the skill shortage problem "...has been forestalled by the introduction of high technology machinery....We have to use high technology to expand". (Recently two "youngsters" were employed to take on the roles of machine minders.)

Moving towards the other extreme a third firm had introduced several NC machine tools as part of a large capitalisation programme. The firm had an elaborate personnel policy, which provided extensive training for the setter-operator. Here the setter-operator had the responsibility of making verifications to programmes, but not of actually writing them. And in the fourth case all the operators were involved in verifying (or "proving") programmes to some extent, and some became involved in the actual programming too (4).

Two other firms were in the process of considering CNC technology, and their intentions were of the two extremes described. In one, a separate department for programming was envisaged - the operators to act as machine minders. In the other, it was hoped that existing setters would carry out their own programming, and some workers had already been sent to possible machine suppliers to examine for themselves the technology of CNC.

In two out of the four cases where NC/CNC was presently utilised, shiftworking was used in order to reduce the pay-back periods of the hardware. But in the other two it was considered that a single-shift system with occasional

overtime was adequate. One of the firms using a night shift pointed out that it was desirable that operators were more than mere machine minders if they were to be responsible for production during the night, when supervisory and technical staffs were more thin on the ground. The other was a much smaller machine shop, and managed to run five CNC machines on a night shift with only one person (the foreman) trained to deal with programming problems.

In all cases there was still one man to one machine, and with extra maintenance requirements, plus the new support function of programming, the number of employees per machine rose. However, although precise figures could not be given, output per employee (productivity) rose significantly in all cases due to the higher capacity of the new machines. For instance, in one small machine shop it was claimed that the five new CNC machines provided an equivalent output to fifteen conventional machines. This was typical of the claims placed on NC and CNC, though in no case had this led directly to redundancies - each firm had introduced the new technology during market expansions. However, one could expect them if and when the firm's markets declined to the size of pre-CNC days.

No firm used piecework for its NC/CNC operators. Two used a group bonus system, one used average earnings (i.e., a day rate plus what they would normally have earned in piecework payments on conventional machinery) and one used a simple hourly rate.

Thus, although in all cases the new technology was used in similar technical circumstances - i.e., small batches and often for the more complex components - there were a range of possibilities for organising work which were recognised and taken advantage of by managers. These were strongly related to the existing organisational make-up of the firm: for instance, where CNC operators were recruited from the existing skilled labour force, their responsibilities were more likely to be wider; and where unskilled or semi-skilled labour was used managers would have to do their own programming (in the two smaller machine shops) or make more use of specialised staff (in the two larger firms). Similarly, the different shiftworking patterns and payment systems used by the different firms were dependent on the systems which already existed - for instance a firm which was generally committed to high technology and had established shiftworking years ago tended to use all new equipment on a shift basis, whilst for two firms which had not used shiftwork recently this was not the case, and one of these two had no intention of using shifts in the foreseeable future. As regards payment systems there was also something of a continuation - the only exception being the case where the temporary use of average earnings in place of piecework was beginning to look permanent.

These strong relations between old and new systems are obviously partly due to the need to maintain some continuity and coordination within organisations. The new technology has to "fit in" with the existing arrange-

ments, especially when introduced slowly over a number of years. Totally separate arrangements are hardly feasible for, say, two or three machines. But one must suspect that they may also be due to certain social and political considerations - in particular workers are likely to wish to carry on the working practices to which they are accustomed. Thus, for instance, in at least one firm skilled labour was used to operate CNC machinery in favour of semi-skilled because of union pressure, and in all cases the payment rates on new machines and the system of bonus pay were both the subject of negotiation between managers and unions (or workers' committees).

The direction firms were taking in terms of the organisation of work were the result of an implicit or explicit strategy which management adopted, and clearly philosophies and strategies varied from firm to firm. This is best displayed by contrasting the two extremes. At one was the owner-manager of the small machine shop who wished to use high technology "instead of" skilled labour in order to expand. He talked about the "illiterate and innumerate kids" on the labour market today: "They're no use to me, so I get CNC instead." By employing two of these young people as machine minders, and retaining all programming functions for himself and the works manager while the existing skilled workers were used as toolsetters, he was already half way to deskilling the operators and creating a small elite of highly skilled staff. At the other extreme was the firm with extensive personnel and training policies, where

setter-operators were highly trained and responsible for expensive machinery. They were expected to set their own machinery and to assure that programmes were correct - if necessary making changes to the programmes. This arrangement was justified by a director both in terms of increased job satisfaction for the operator and in terms of the advantages of having a flexible and responsible workforce. As the director said: "it pays". Nonetheless, the work organisation in this firm was no doubt strongly related to a philosophy of, to use management's words, "participation" and "delegation of responsibility".

To summarise, organisational forms characteristic of NC and CNC technology were strongly related to existing forms - partly for technical reasons of continuity and coordination, but also because of political forces deriving from vested interests in existing arrangements. However, the management strategy is not, in the end, determined by these factors, and whatever the real relation between strategy and ideology, managers did perceive their "philosophy" as playing a central role.

The variety of organisational designs found in machine shops were in many ways similar to those found in other manufacturing concerns where electronic process control devices were being applied, and the mechanisms at work were the same.

Miscellaneous Manufacturing Processes

As with machine tools, electronic control of other manufacturing machinery eliminates the operator as such, and concentrates the skill in the pre-setting of the process. Again, managements' designs were different in different firms - their organisational intentions ranging from an attempt to "deskill" a "problematic workforce" with high absenteeism and turnover rates (thus placing control of work in management hands and making labour easily replaceable), to plans to combine several functions (including even maintenance) so that each highly trained "professional engineer" would be responsible for one machine.

It is particularly interesting to juxtapose these two particular cases, since the first represents a logical response to "labour problems", and the second also represents a logical response - to exactly the same labour problems: high turnover and absenteeism. The two firms are entirely different - the first being a small plating company and the second a large tyre manufacturer, but the particular issue here is the same. The first firm constitutes one of our major case studies (see chapter 8) and as we will see their labour problems were not altogether solved. In the second firm, unfortunately visited only once, there were some unresolved conflicts between various interested groups of employees over who should have control of the new system. When management try to implement the system whereby a new type of technician takes responsibility - cutting across several traditional job boundaries - one must expect further

conflict.

The control implications are fairly obvious, and in some cases managers spoke quite openly about "taking control away from unreliable workers", "deskilling the jobs", "making supervision tighter", and so on. Where the operator's work was upgraded, managers claimed that "bringing interest back to the job" would bring the more important benefits of a motivated and reliable workforce. More overtly political control issues, however, were raised by machine monitoring systems:-

In two cases machine monitoring systems were being introduced as part of the new electronic control devices. In one case this took the form of a simple digital read-out on how fast machines were running so that the supervisor could see at a glance machine speeds. The reason was that operators would often run the machines slower than was possible in order to make their work easier. In the other, an elaborate system could communicate to management machine speeds, downtime frequency, and a host of other information. The intention in this case was ostensibly "to monitor machine performance, rather than the man", so that problems with machines could be rectified quickly. But the distinction was clearly difficult to draw, and management themselves pointed out the likely problems with the "big brother" aspects, which are expected when the system is implemented.

In several cases managers complained that the transition to the new systems were marked by operators "carrying over bad habits" and "still using old ways of working". In

fact in two cases - one on the handling equipment associated with a forge, and one on an automatic plating line - operators would use the manual override in order to manually control what would otherwise be an automatic process. (The same occurrence was, in fact, found in one of the machine tool firms.) These practices, of course, represent a real failure to implement the new technology - old methods are maintained in favour of the new.

Again, shiftworking patterns and payment systems were more a reflection of the existing organisational set up rather than a result of the new methods. For instance all the firms applied their existing payment systems rather than devise and apply new ones to what was often incremental change.

Summary

These case studies show that a variety of organisational forms exist in different firms using very similar manufacturing equipment and techniques, and that the type of work organisation which evolves around new technology is dependent on a managerial strategy which mediates the "impacts" of the technology. They also indicate that this management strategy necessarily takes into account the existing organisational arrangements - which are in any case partly the result of the same underlying management philosophy. Workers and their representatives were also seen to bring some influence to bear on new patterns of organisation, and one must suspect that, at least at the

level of shopfloor interactions, workers negotiate or "bargain out" detailed working practices.

However, these pilot studies do not show us how the processes of strategy formulation and negotiation really work, and they necessarily fail to take account of all the interest groups involved. That is, they are only "snapshots" of organisations, from the viewpoint of leading managers. Only longitudinal studies which map developments over time and describe the social "dramas" leading to the establishment of new ways of working can properly explain change processes. Our more detailed case studies attempt precisely this.

CHAPTER EIGHT

THE PLATING COMPANY

Company Background

The company is concerned solely with plating processes. Zinc, aluminium, chrome, etc. plating is carried out on components mainly of steel. The market has become more unstable very recently, but a deliberate policy of avoiding the motor industry (most components find their way into other consumer goods - refrigerators, washing machines, and so on) has meant there is still no shortage of orders, and the workforce still enjoys as much overtime as it requires. The firm consists of about fifty people, including management.

Being privately owned, the firm was set up in 1964, the owner later passing on the concern to his two sons, who together with a third partner now own and direct the company. Of these three owners, two deal with the technical and production side of the business, and one with the sales and financial side. They employ a works manager who deals with the day to day running of the shopfloor, and a chief maintenance engineer who has a major role in developing, as well as ensuring the efficient functioning of, manufacturing processes. These five people are the management team, and between them make all the major decisions of the company.

The workforce consists mainly of unskilled Asian and West Indian labour, many of them women, and there is no

union organisation.

The Changes

Very briefly, during 1980 and 1981 the firm changed location to a custom-built factory about a mile from the original site. A move was inevitable - the old premises were decrepit, and both the Health and Safety Inspectorate and the local Council were placing increasing pressure on the firm to move out. Physical working conditions in the old factory could only be described as hellish - in particular the whole place was wet and cold, there were large holes in the concrete floor where corrosives had eaten it away, and unpleasant fumes filled the air. One of the two brothers who own the place (hereafter referred to as "the general manager", since this was, effectively, his working role) made a direct connection between these conditions and the high absenteeism and turnover rates. Figures were not readily available, but "it's commonplace to see three or four leave on Fridays" and absenteeism "is about ten or fifteen per cent". The monotonous nature of much of the work was also stated as contributing to this "problem of unreliability".

During the move to new premises - that is, when the old plating equipment was being installed in the new plant, two of the plating lines, out of a total of five, were automated. The firm had first experimented with an automated system on one of the lines in 1974, but the technical problem of flexibility held the project up. Changing from one

process to another meant going back to the manual stage and resetting, which could take around two hours. Before the flexibility problem was solved the control system supplier went bankrupt, and the project folded. The new control system supplier was "chosen more carefully", and this time the system caused few problems. With the new system, changing the process is carried out at the control panel by changing the programme and/or the time settings. This is far easier and quicker, greatly enhancing flexibility. On the last visit (May 1981) the automatic lines had been running for three to four months, and the basic technical problems had been ironed out.

The cost of shifting location was around £400,000, and although at the best of times plating processes are not the most pleasant to work with, physical conditions are unmeasurably better. However, the importance of the physical improvements for our concerns lie only in their incidental relation to the interplay between the work organisation and the new control system. The new control system itself was in comparison a small investment - only £10,000 including programmes. This partly reflects the decreasing costs of sophisticated electronics, but was mainly because the new system was "added on" to existing equipment (1). But for the organisation of work within the firm the implications were and are very important.

Management Motivations (2)

Before the changes the general manager was unambiguous about the reasons for automation: the firm wished to expand production; a fixed price for the expansion was particularly attractive ("machines don't need wage increases"); and the labour force was "unreliable". Automation gave the opportunity to expand production without expanding the labour force.

However, when questioned about what jobs would be like on the automated lines, the general manager made it clear that the "unreliability problem" refers to more than just high turnover and absenteeism. With the manual system, platers (the men who work on the plating lines) had a good deal of control over production - both quantity and quality - and apparently could not be trusted. In particular, platers would often increase plating time, which makes their work easier, but wastes time and plating materials for the management. The works manager was even more forthright, with comments such as "they can't be trusted", and frequent reference to the notion that some were not very intelligent. Going automatic was to be the answer to these problems too: the platers would no longer control the process, for the control system would be completely in the hands of management: "We want the operator to just stand there and watch, and stop it if things go wrong."

We will now describe in some detail the changes which took place, and the extent to which management's expectations have been met in practice.

Implementation

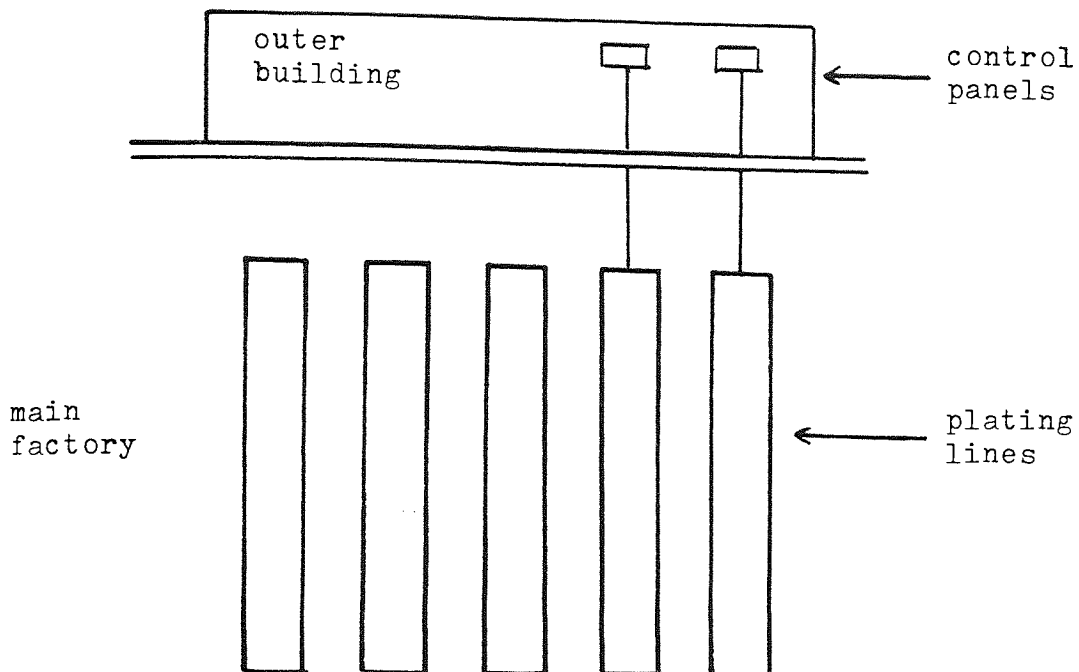
The platers are all men (3), and there are normally three per line for a total of five lines. On those two lines which have been automated, however, only two platers for each are now employed (4). Thus even if these lines have only the same output as the old ones, the new control systems should pay for themselves in less than a year (5).

Apart from this displacement of "unreliable" labour, the major advantage of the new control system is its use in taking control of the plating process out of the hands of the plater. A brief description of the process and job tasks will help to make this clearer:

On each plating line a set of rails runs along the top of a series of vats containing the various solutions necessary for the plating process. A carriage runs along these rails, dropping and lifting containers or jigs (holding the steel components) into and out of the various solutions in the vats. With the manually controlled system, after loading up the carriages the plater has to walk alongside (or on some lines, ride with) the carriage, controlling its movements with an attached control lever. Depending on the type of component, the finish required, etc., they are shifted in and out of the various solutions for different amounts of time. On satisfactory completion of these processes the carriages are unloaded, and the process can then be repeated. We can thus see how platers could easily control the quantity and quality of their work. In the absence of any form of bonus system, management control was largely

dependent on close supervision. But no matter how close, the platers maintained a good deal of control, and management's intention with regard to production targets and quality were frequently not met. Automation should mean that (i) "unreliable" or "stupid" workers would now just "stand and watch" - management should now control the process, and (ii) "anybody can load and unload and monitor the process - the skill isn't in the plater's hands any more". Thus high labour turnover should no longer be a problem - "anybody can do it".

Computer control of the plating lines means that the movements and timings of the carriages are pre-set by feeding the necessary information into the plating line's control panel. Occasionally this involves some programming (carried out mainly by the system supplier, although the chief maintenance engineer is learning quickly) and frequently requires the resetting of the timers. Apart from loading and unloading, the process is then (theoretically) automatic. In explaining how the automatic lines work, the works manager illustrated his discussion with a visit to the shopfloor to see the control panels. Almost unbelievably, this involved walking straight out of the other side of the shop, and into a small building around the back. Here, amongst other electrical equipment, were the control panels. "The platers can't get at them here", he said. In effect, the control panels were separated from the plating lines by a wall, as is illustrated in the diagram below:-



When asked who sets the process controls he smiled and said "I do". In fact only three people are allowed to tamper with the controls. These are the works manager, the general manager, and the chief maintenance engineer. The control panels were placed behind a wall for no other reason than to prevent workers tampering with them, and management have made no secret of the fact that the intention is to wrest control of the plating process out of the hands of a problematic workforce (6). However, the working practices which have emerged have not entirely met management's expectations, and we will now examine in more detail exactly what has happened.

Evolving Working Practices

The works manager, when discussing the reliability of the automatic lines, pointed out that occasionally something goes wrong. For example, components may come out too dull, and the whole batch might have to be scrapped. With the manual system - that is, with the plater in control of carriage movements and timings, he might leave components in the necessary solution for a few seconds longer than prescribed, or return the components to the appropriate vat quickly enough, etc., to rectify any slight deviation in conditions. But the automatic line, of course, carries on, and not being in control, the plater is far less likely to spot slight deviations, meaning that work may be spoiled (7). If the plater monitoring the process is capable of spotting deviations at an early stage, then the scrap rate can be significantly reduced. But this is dependent on at least some observational skills. One experienced plater (he had worked on the lines for five years) was quick to point this out, claiming that overall quality of work even on the automatic lines was far better in his hands than in those of less experienced workers.

To cope with these occasional problems the machinery is fitted with a manual override which is accessible to workers. Using it is a simple matter of flicking a switch from "auto" to "hand", and its occasional use to adjust the programmed process can make the difference between good work and scrap. This is most often the case when new programmes are being adjusted or proved for the first time,

and it is thus especially important that platers are involved and motivated during the first few months of automation.

Another example of this stochastic intervention which was particularly important during the first few weeks of implementation was related by platers. Occasionally a carriage would "miss" a barrel-full of components and carry "thin air". At best the components would remain in a solution for too long a time, and at worst, the carriage would bring another barrel and attempt to lower it into the same vat (which is now empty as far as the computer control is concerned) causing a collision - the result of which could have been extremely dangerous. Here intervention had to be fast and decisive, and fortunately no major accidents occurred (8). Again, use of the manual override (after, of course, the emergency stop button had been used) saved a good deal of time and trouble.

However, although manual intervention has been (and often still is) important to maintain production, the operator's frequent use of the manual override contradicts one of management's basic objectives in automation - taking control out of the hands of workers. Thus the works manager complains that:

"....some operators still do not adjust to the automatic lines. They use the manual override if you don't watch themIt's a bad habit. It's difficult to get it into their heads that automatic is the best way. They think they can do a better job manually."

Some of the platers expressed at least some pride in their work, and would frequently use the override to gain

exactly the finish which they considered constituted "a good job". This partly explains their preference for the manual method, with management having problems in convincing platers that the quality of finish they were achieving through manual intervention was higher than necessary, and that the finish achieved by the automatic process was sufficient (9).

Besides a surprisingly strong sense of pride (given the poor working conditions and the monotonous nature of much of the work) in a "good job", the other reason why platers would use the manual override was to control the pace of the line. In particular, loading and unloading the lines could become hectic, especially since there are now only two platers per line. A simple flick of the switch from "auto" to "hand" gives instant relief from mechanical pacing. Platers can also control pace simply by loading up less carriages, allowing them to carry "thin air" - though this method is, of course, highly visible. In sum "we can slow down a bit when they're not looking", and "they still come round telling us to hurry up and get the work out". Thus close supervision is still heavily relied upon.

What seems to have happened, then, is that in being involved in the implementation of the new control system - in particular in having to remedy the mistakes made by the new system until it was "debugged" by frequent use of the manual override - workers have at the same time been establishing working practices. Now that the technical problems have been ironed out, management feel they are in a position

to use the new system as originally intended. However, working practices are now to some extent "institutionalised", and management are finding great difficulty changing them (10).

This "problem", ironically (but predictably) is now compounded by the fact that the vast improvements in physical working conditions with the move to the new factory has meant that labour turnover has virtually ceased. All those now concerned with the new methods have stayed with the company throughout the changes, and there are no signs that they may leave in the future (11). In other words, management's "unreliable" workforce have suddenly, in one sense at least, become reliable - i.e., they turn up every day. However, they are still considered unreliable in the sense that they "cannot be trusted", leaving managers in the unsatisfactory position of having a workforce still in control of quality and pace of production.

CHAPTER NINE
THE OPTICAL COMPANY

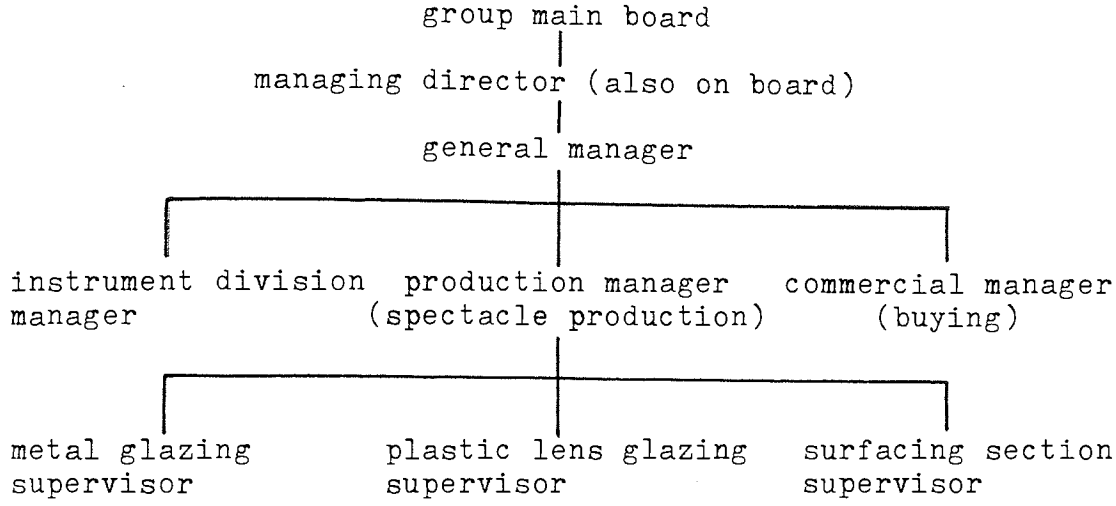
Company Background

This optical company is concerned mainly with the manufacture of lenses and the making of spectacles to prescription (a prescription comes from the optician, and a pair of spectacles is returned from the factory to the practice). About 1,600 to 2,000 pairs per week are produced. A small but expanding section of the company is the Instrument Division, which designs and manufactures industrial profile projectors for inspection functions in a range of industries. This section, however, has only two or three employees, and will not be a concern of this case study. Recently the recession has begun to affect even this company, and although the slight drop in sales is unlikely to seriously damage the firm in any way, its expected expansion will now be delayed for the foreseeable future.

The company belongs to a group of companies which altogether employ about 350 people, with total sales of around £4m. The optical company itself employs 45, and its own sales are about £1m. The group includes a chain of Midlands optical practices, and although the optical company is closely connected to them, a customer-supplier relationship is maintained. Operating very autonomously from the group - the directors rarely being seen even by the general manager - there is a good deal of room for internal manoeuvre. A capital sanction scheme is operated

by the group, but "once the capital is approved, we can swap and change our investments".

Including foremen, the internal management team consists of seven people, and can be represented as follows:-



The Changes

Since 1978 the whole factory has been rationalised, reorganised, and modernised - all under the direction of a new general manager who was appointed just prior to that by the group main board. Before his arrival all production was in one room, which he described as "a maze". The surfacing and glazing sections were segregated, production "lines" were straightened up, and a computing room was created. At the same time the general manager set up the machinery for the collection of data on internal trends - rejection rates, maintenance requirements for machinery, and so on - so that remedial action could be taken on problems and bottlenecks, which were spotted more easily. Also, the group bonus system was reorganised so that workers

could understand its mechanics more easily, and so that bonus pay was related more directly to output.

The most interesting changes for our purposes, however, are the new pieces of machinery and equipment which have been introduced over the last few years. The firm now prides itself as "one of the most advanced producers of spectacles in the UK".

New Equipment

In the surfacing section (1) the firm has for some time used automatic machinery - rather than hand controlled machinery - whereby the machine is set, switched on, and the rest is automatic. (Hand controlled machinery still has to be used for some jobs.) The task of setting itself, however, has recently been simplified through the introduction of a computer. Previously a skilled worker would receive a prescription for the lens to be made from the optician (every lens is unique) and from this would make "rule of thumb" guesses as to which blank to use, and which tools and settings to apply. Before being made perfect, the lens may have to be "recut" several times - surfacers would tend to underestimate their initial calculations because more can always be taken off the lens, but not put back on. Blank selection, tool selection, and machine settings can now, however, be predetermined by use of a computer, which is programmed to translate that information into which machine settings, etc., to use (2). The woman who does this "computing" sends the information from the computer room upstairs to

the surfacing room. The surfacers can then simply follow the instructions on the ticket to select tools and set up machines. An accurate lens is then produced in one cut, meaning faster production runs; and the elimination of guesswork means a far lower scrap rate (3).

In the glazing section (4) the firm has, over the last few years, introduced a variety of automatic equipment. This includes automatic edging machines - which shape the lens to fit the frame, and put the 'V' on the lens which allows it to be held by the frame; and electronic foci-meters - which make the task of lining up the lens for an accurate fit in the frame far simpler. A small production line is set up in the glazing section, and the various tasks involved are rationally segregated. Taken together, the new machinery and the division of labour on production line principles take a good deal of the skill out of the work, and this aspect of innovation for both surfacing and glazing sections will now be discussed.

Deskilling

The firm's policy towards production machinery is to buy the best and the most modern. The general manager and the production manager make the choices of particular machines and pieces of equipment, spending a good deal of time visiting exhibitions in Europe to ensure that they are up to date with the latest. They try to replace most machinery "every five years" in any case, and as innovative machinery comes on the market they buy it.

The deskilling which most of this modern equipment entails is seen as an unfortunate side effect which management themselves would not have chosen. The production manager and the metal glazing supervisor are particularly articulate on this matter, both having been in the business most of their lives, and both still considering themselves to be craftsmen. They talk about the change from highly skilled craftsmen to semi-skilled machine operators, and this transformation is perhaps most clearly seen in the case of surfacing, where the surfer's work is reduced largely to carrying out instructions on a ticket which comes from a computer. The extent of the deskilling is perhaps best displayed by reference to the new surfacing supervisor, who is in fact a master glazer. He has been in the surfacing section for several months only, but by working to computer print-outs his work is as good as anyone's, and he is perfectly capable of supervising the section.

The lens computing, on the other hand, involves about six months in training and experience to be carried out competently (surfacing section supervisor's estimate), and thus hardly represents a real "transfer of skill". In fact, the skills involved in surfacing have now been divided between first, the surfacing machine setting and operating; second, the computing; and finally the programme writing. The latter task has now been largely completed by a consultant, in conjunction with the production manager, although improvements to the programmes are occasionally added, and constantly sought.

The typical attitude of the experienced surfacers to the new machinery, according to their supervisor, is that they "admire the new machinery, but prefer to work with the old". The supervisor also comments that surfacers, during the transition period, would always blame any faults in finished work on the computer. But now the computer is trusted and accepted as reliable, and tooling is the first thing to be examined when anything goes wrong.

In the glazing section a small conveyor transports the spectacles from work station to work station, and workers carry out fragmented tasks as the work reaches them. The lenses are prepared for glazing by being lined up on focimeters, then ground at the edges on "edging machines" (5). Moving down the line, they are then "rammed in" to the frames, before being rechecked and finely adjusted, using once again a focimeter. In this section, therefore, both new machinery and a fine division of labour based on that machinery (i.e., there are focimeter operators, edging machine operators, etc.) means deskilled work for the glazers.

Given all this "deskilling" (to use management's own phrase) one might have expected the managers to take advantage of the "control" possibilities. That is, the quality and quantity of production could have been controlled directly by management, rather than relying on the judgement, skill and discretion of the workforce. In particular, skills could easily have been concentrated in the hands of a very small elite of technicians, and operators trans-

formed into unskilled, cheaper, and replaceable labour. Further, the pace of production could have been controlled in far more direct ways than through a simple group bonus system (6). But this was not the course taken, as we shall now see.

Job Rotation

The general managers and his supervisors talk enthusiastically about the technical advantages of the new machinery, and spend a good deal of time keeping up with the latest developments in Europe. As we have already mentioned, the production manager as well as the general manager try to visit other companies in Europe, and often travel to the exhibitions. In fact to hear them talk one suspects the interest to be as much a hobby as a simple concern to improve the company's efficiency (7). But they are unhappy about the effects the new machinery has on the workforce. For instance, after describing at length what a "remarkable device" the new focimeter was, the production manager complained that:

"....there's no training needed to operate this, so it's deskilling the job and I don't like that, I like to train somebody....All you need to know is about four different movements, whereas on a focimeter (of the old type) you have to know what you're doing - you have to know the plus and minus aspects of the lenses...."

It was the general manager, however, who was responsible for introducing the idea of job rotation. Arriving only three or four years ago, and bringing with him a strong

philosophy of participation and involvement, he has now managed to establish job rotation as an institutionalised (and compulsory) practice, so that workers now automatically rotate regularly from job to job, and so that any new recruits are given training in a range of functions (8). The immediate psychological advantages of rotation are obvious:

"....the staff like it, they like the change. Because there's some boring jobs out there!" But job rotation is connected by the management also to a set of advantages which are economic to the firm.

In particular, rotation means that absences due to sickness or to holiday can easily be covered. As the production manager pointed out:

"....when the holiday season comes on, and I say to a girl, 'look, you come here and work that machine', we're OKthe staff are now reaching a point where I can move them around anywhere I want - and that is a wonderful thing for a production manager to say."

Similarly, a multi-skilled workforce means that shifts can be used with a minimum of supervision. A two-shift system is a possibility for the future, and the general manager considers that this advanced preparation is vital.

Also the psychological advantages themselves were pointed out as having direct economic advantages in terms of increasing motivation and involvement in work, thus decreasing the possibility of errors (which can be more costly on expensive machinery) due to inattentiveness.

Alongside the rotation of jobs was a policy of careful personnel selection - at least a "certain level of compe-

tence" was required - and this not only ensured a minimum capability, but provided possibilities for promotion to supervisory jobs in the future. Four of the recent recruits were in fact undertaking apprenticeships, and the expense involved for a firm as small as this is perhaps the best evidence of the firm's determination to maintain and utilise a skilled and flexible workforce, rather than a set of specialised, deskilled machine minders.

To summarise, we might characterise the firm as being the recipients of a Tayloristic technology designed to deskill what is traditionally a craftsman's domain. To alleviate the worst psychological effects, and to ensure a responsible and flexible workforce, the management have introduced an extensive and very serious system of job rotation. This does not mean that craft skills are retained - on the contrary, the tasks involved are very different and the processes are more and more resembling "a science rather than a black art". But it does mean a very different way of working than would otherwise be the case, and this is reflected in the large amount of time and attention paid to training. The importance of the firm's management, then, in shaping the social and technical organisation around the latest spectacle producing machinery, should not be underestimated.

CHAPTER TEN

THE RUBBER MOULDING COMPANY

Company Background

The main manufacturing process of the division concerned is precision moulding of medium to large batches of rubber components, and about 80% of total output goes either directly or indirectly to the automotive industry. In 1974 there were 650 employees, but since then, through rationalisation and the updating of manufacturing techniques, numbers have been reduced to as few as 350 employees, even though output is now slightly higher (1).

The group to which the company belongs is a large one, employing several thousand in all. However, the company does operate fairly autonomously from the larger group in terms of internal organisation and decision making. For major technical decisions the technical manager and general manager appraise the possibilities, and forward proposals for sanction by the group.

The Technical Changes

In 1975 two major new projects were embarked upon by the firm. Both were internally generated, and according to the technical manager were to remain competitive - improved quality and cheapness being the primary considerations.

The first was injection moulding, to make components previously made on steam presses. The new injection moulding process vastly increases productivity, through increasing

the number of parts per mould, and more importantly through reducing cycle times (the previous cycle included twenty minutes just for the rubber to become vulcanised; the new time is less than two minutes).

The second was flashless moulding - a new method of transfer moulding. Again the number of parts per mould is increased, and in this case an advantage is that there is virtually no process waste.

Both processes are electronically controlled (the control devices are solid state), and it is the new requirement of setting and adjustment of electronic control devices, along with the new maintenance needs, which have the most important implications for the reorganisation of work (2).

Expectations on Introduction

The first of the changes was injection moulding, and the new injection units were gradually introduced straight onto the shopfloor from the machine manufacturers. Supervisors and operatives were slowly introduced to the new machinery, which was placed in a partitioned-off pen in the middle of the production area. Flashless moulding was introduced in a similar manner.

Management intentions with regard to tasks were to separate more completely the labour involved in (i) setting and adjusting machinery, and (ii) operating machinery between process control and operating functions. The process control department was expanded to meet this desire, and training needs became far more complex with far more para-

meters to control, and faster cycles necessitating more precision. Supervisors and maintenance workers (mechanical and electrical) needed extra training to cope with the new processes, and this was done in conjunction with the machine suppliers. For operators however, according to the senior process controller: "it's just training for a different mechanical task". No special training was given, apart from on-the-job teaching.

With regard to payment and effort, management intended to maintain the existing piecework system - the piecework part of the wages providing a significant amount of the operatives pay, and (theoretically at least) the degree of effort critically affecting this portion.

The strongest explicit concern of workers and their representatives during introduction was that operators who were currently employed should be given the opportunity to man the new units. Mainly because the new work was far less strenuous, the union did not want outsiders taking the new work. As a shop steward put it:

"....when these presses were implemented (....) we didn't want new labour on there; we wanted existing operators, to give them a chance to come off the heavy job onto the lighter job. These, flashless and injection, they're a lot lighter work - it's nearly all press buttons, whereas we'd been working on the loose moulding, the heavy stuff, say ten fifteen years....Which I think is only common sense really - people have been working for ten years on a heavy job and a new piece of machinery comes in where you've only got to press a button; you want your blokes to work that machine don't you - pressing a button instead of throwing moulds about.

And that's the way we worked it. The blokes off the old heavy jobs first and then bring new labour in. In fact, every person now working on injection and flashless have worked on the.... heavy moulds."

Alongside this concern to keep the work "within the family", the workers saw that the new moulding units produce more parts more quickly, and at less cost. As the manufacturing manager informed me: "...the firm was not only using its most expensive labour in the loose moulders....but was also facing demands for a slice of the cake".

In sum, sources of manpower, the division of labour, and payment and effort were the major contentious issues on the initiation of the project (3). As we shall see, during ensuing negotiations the three issues became inextricably intertwined, and it would be inadequate (if not misleading) to describe the developments as if aspects of work organisation existed independently (4).

"Productionisation" (5)

Over the next couple of years the new processes were established within the firm, and not until the end of 1977 for injection moulding, and the end of 1978 for flashless moulding, were agreements with the unions over payment schemes and systems of operation finally thrashed out.

In both cases the machinery was introduced straight from the supplier to the shopfloor, and before anything like full-scale production could be set up some development and adjustment to accomodate the firm's particular needs

had to take place. Management's first problem arose almost immediately. According to the manufacturing manager: "Development in the production environment meant that the operator would productionise machinery, and rather than management giving production parameters to the operators, the operators would to some extent give them to management." In other words, workers became very familiar with the units, performing wider functions than was expected of them - for example some routine maintenance and process control setting. Management would have preferred process control and development staffs to establish the processes. They suggested that "green labour" would have learned the limited and specialised tasks more quickly, not carrying over "bad habits" (6). Also, productionisation would have been left to the appropriate personnel had new labour been recruited (7).

However, the major problem which management found, and the one which took up most time in subsequent formal negotiations, was that of re-establishing piecework rates on the new machinery. Operators might be persuaded to call in the process controller rather than tamper with the settings, but payment and effort were central and legitimate union concerns. This does not mean that the other problems mentioned above were necessarily peripheral ones. Rather, those areas tended to be subsumed under the problem of the payment-effort bargain. As we shall see, the issues were inextricably linked.

On introducing the machinery, piecework payment would

obviously not be possible until technical problems had been ironed out and employees become familiar with the new processes. Thus during this phase operators were paid average earnings (the amount they had earned in previous months in the old press shop), and this regardless of effort. At the same time operators were becoming very familiar - if not technically competent - with the processes.

About six months after the introduction of the first injection unit management decided the time was ripe to introduce piecework. However, operators were enjoying average earnings and resisted this move. Another twelve months passed before an agreement was reached. Management eventually "bought out" the operatives average earnings by slightly raising, and backdating, the standard hourly payment - to be paid in a lump sum. And for the piecework portion of pay, it was agreed that the new technology should yield an earnings potential equivalent to that on loose moulding. However, with the mechanics of the payment-effort bargain at last established, the work study engineers still had to put prices on individual jobs. Here, because of their involvement in productionisation, operators found that they were in a favourable position to use the various technical "hiccups", etc., to justify higher rates than the time-study man would normally allow. Today - a couple of years later - the chief work study engineer feels that "fair" rates have now been established:

"Certainly now, the things that an operator can do to beat the system if you like, are generally now known....So I

think we now know far more readily the sort of things that they can do. We either then accept that - we'll still pay for that - or we change the method of operation if it's something that has changed on the process....So, on that sort of thing it's generally brought to light now far more readily."

But these problems were enough for management to have "learned our lessons": in future productionisation will be carried out away from the shopfloor.

Emergent Work Organisation

Probably the most striking change in work organisation is the substantial transfer of skill from the shopfloor to the office. In particular, although shopfloor operatives had always been classified as semi-skilled, the more experienced workers and the foremen in the loose moulding area previously played a major role in setting and adjusting machinery. Now it is more or less established that setting is carried out by process controllers. The senior process controller commented: "They (operators and foremen) like to have a twiddle. The only control we don't mind them adjusting to a minor degree is the injection pressure control (8). Apart from that we like them to leave it alone". In fact, operators never fully developed a desire to set and adjust machinery. They were convinced (rightly or wrongly) that it was beyond their capabilities. A supervisor told me: "...process control - they're experts at that kind of thing....they decide all the settings, the timings, the cure times and everything. Our chaps couldn't

do that, well, I couldn't do that". The impression given was that this issue was channelled into the overriding concern with payment and effort, the question of who controls the immediate work process being treated mainly as incidentally important (9).

But divergences from a strict division of labour do occur frequently, and as with the above "twiddling", they are encouraged by management when a slight deviation from the rules will help production along, and sought by workers when they might increase piecework payments. Occasionally both managers and workers feel they gain from this. The chief work study engineer provides an example:

"....in the flashless....we have knowingly allowed for operators to go around the back of the machine, every cycle, to open the guard at the back and ensure that the surface - the undersurface of the pattern - is clean. Sometimes you get pips sticking in. We have purposely allowed that in the system, and we pay them on every cycle based on an average that we measured during extensive studying. We now know that that does not apply on every cycle - so they can gain a few seconds on every cycle by not going around. They might go around now once in every five cycles instead of every cycle. But we still allow that frequency of one in one...."

Workers will also, of course, use any other means to beat the system. For instance the Work Study Department is currently keeping a close watch on the amount of time booked as "waiting time": "Operators are booking waiting time while still running the presses. The less time booked on the job, the higher the performance".

However, overall the possibilities for beating the

system have been greatly reduced: "...that opportunity has been reduced on the new technology....because the jobs are of a more repetitive nature and you know what is likely to happen. Older processes, it was more of an operator's individual ability to overcome certain problems which obviously meant everybody learned". And as a supervisor said:

"On injection....being governed by the machine we can tell how many heats they can do a day - what's the maximum performance they can do....In loose moulding they could (go above that performance) because, as I say, the faster they go, the more they can do. If they had break-downs they could do so many heats and put a waiting card in - say for about three hours - and you're getting cards in with a two hundred performance or something like that! And you could argue and argue but you couldn't prove that they couldn't do it. But on the electric machines you know exactly the amount they can do. There's no way they can overbook."

(In fact workers still do overbook according to the chief work study engineer. But this overbooking can now be done only up to a known maximum performance.)

We should also note that when agreements on the new technology were finally reached, the union negotiators managed to gain a 16% relaxation allowance. Again, because operators were involved in productionisation they were familiar enough with the machinery and its problems in operation to negotiate a higher rate than might otherwise have been the case. Today there is a continuing argument over interpretation of the allowance. Instead of using the resting time intermittently, as management intended, many

workers will work at full pace for most of the shift, and then relax for the last hour or two.

Lessons Learned by Management, and the New Development Area

Although management expressed no dissatisfaction with the eventual outcome of the changes, they saw enough problems in productionising on the shopfloor to convince them that a separate development area was vital for any new projects. This has now been built, and three major new processes are being developed within it. Unfortunately they are at the moment confidential (to keep the information out of the hands of competitors) so we cannot go into detail, but the expectations with regard to work organisation were made clear by the manufacturing manager. Productionising away from the shopfloor means that the establishment of working practices and of piecework values will be far less problematic. As soon as the new machinery comes into the hands of the production function full-scale production will be immediately possible, and negotiations straightforward: "...once you've negotiated and established a time it's a hell of a job to change that".

Already the production managers feel they have benefited from the new development area, since new moulds for new components are now developed here. Thus each time the product changes operators do not any longer have the same chance to use their own preferred work methods. These are already established in the development area before the new work comes onto the shopfloor. But through pressure of

getting work out to customers the theoretical benefits are not always realised. According to the chief work study engineer:

"....jobs will go out to the production shop in a condition we cannot put a piecework time on - it's not consistent....and that ends up then with us paying an average earnings form of payment to operators, and obviously operators, they want piecework really....But after a few weeks of average earnings they don't want to go back onto piecework. There's a little bit of resistance...."

Exactly what happens when the new processes are introduced is yet to be seen. The important point here is that through their experience, management have come to see the new means of productionisation as their way of taking this phase of technical change outside the sphere of influence of machine operatives (10).

CHAPTER ELEVEN

THE MACHINE TOOL MANUFACTURER - MACHINE TOOLS

Company Background

The company is a major machine tool manufacturer located in the West Midlands. It changed hands in the mid-1960's, and again in the mid-1970's. In the summer of 1980 the firm was taken over by an American-based transnational corporation. The first research visit was just before US involvement, the bulk of the research being carried out in the autumn of 1980 and the first few months of 1981.

Back in the 1950's there were over 2,000 employees at this site, but since the late 1960's the figure has been less than 1,000. With the impact of the current recession, numbers have fallen from around 650 in April 1980 to 550 in October, and down again to around 450 in May 1981. The latest redundancies came after a three day week had been worked by most sections of the shop for around six months (1). The manual worker to staff ratio is 1.85:1, and of the manual workers almost 70% are recognised as "skilled", about 20% "semi-skilled" and 5% "unskilled". There are about twenty apprentices. There can be little doubt that the formal "skill structure" of the manual workforce is partly the result of trade union preferences (2), but certainly there is a high proportion of very highly skilled manual workers.

The firm produces a range of conventional and computer-controlled machine tools, many for export, and most to customer specification. Production is mainly in small

batches, and the major operations are casting and heat treatment, machining, and assembly.

The US parent company have so far left the internal management structure intact, and for manufacturing innovations today the central figure is the manufacturing director, who actively involves himself in all aspects of technical changes. Together with the managing director he makes the major investment decisions, although as we shall see many other actors are very important.

Representatives of the American firm have visited the plant on several occasions, but mainly at boardroom level. Any influence on internal organisation for manufacturing will thus be through the manufacturing director, and it is difficult to decipher exactly which aspects of managerial policy and strategy come from the American firm, and which from the internal directors. However, one may expect that the US corporation will generally seek a radical rationalisation. Certainly managers inside the British firm expressed this expectation, and according to a recent article in the Financial Times: "More products from an unchanged or smaller workforce is a recipe which (the American corporation) has successfully applied to a long series of acquisitions within the US".

Chapter 5 pointed out the types of technology characteristically being introduced in many machine shops today. This firm provided the opportunity to study two of them - computer numerical control of machine tools (CNC), and computerised production control. CNC is the subject of this

chapter, and the changes in production control make up chapter 12. Both provided excellent insights into the ways in which social and political considerations come to be "built in" to aspects of the technical organisation of the firm, as we will now see.

Computer Numerical Control of Machine Tools (3)

The first CNC machine tools for use in production were introduced only four years ago - even though the firm had been manufacturing CNC machinery for over ten years before that. Today nine CNC machines are being used, and there are plans to introduce more in the near future. As we have seen, the technical and economic advantages of NC and CNC machinery over conventional machine tools are potentially very substantial, and the firm's adoption of computer control should obviously be understood in this light. However, as we shall see, the exact type of equipment chosen and the way in which it was and is utilised is dependent also on certain social and political considerations. We shall concentrate on these.

Since the first CNC machines were introduced there has been a change in the senior management team (an important point, the significance of which we shall see later) and thus it is difficult to talk in detail about motivations for the choices of particular machines. The way choices are now being justified can be examined, but a discussion of choice of hardware will be left until after a description of the evolution of current working practices, since these are now taken into account in decision-making on new technology.

Technical Description

Eight out of the nine CNC machines currently utilised were designed with the intention that programming should be carried out away from the shopfloor - the result of the programmer's work in the office being a paper tape which, when installed in the machine's control cabinet, directs the movements of the machine through a series of electro-mechanical devices. However, the machinery is CNC rather than NC, meaning that the control cabinet on the machine tool itself has an "editing" facility for "proving" tapes. Thus faults in programmes can be rectified on the shopfloor during the production of the first component of the batch. This is done by stopping the machine and rectifying faults in the programme as and when they appear - the control panel bearing the appropriate devices for this task. (With NC the programme would make frequent trips to and from the office for faults to be rectified.) Corrections are stored in the memory of the machine's own computer, and once "proved" the rest of the batch is made automatically from the instructions now in the computer memory rather than those on the paper tape. If corrections made have been significant, and if the programme is to be stored in the office for future use - which is frequently the case - then a tape punch can simply be attached to the control cabinet, punching out on a fresh paper tape the modified programme. Thus next time the same component is required, assuming no design changes in the component, the editing stage is omitted. Five of these machines are turning machines, and the other

three are machining centres - used mainly for milling, but also boring, tapping and other functions.

The ninth CNC machine is also a turning machine, but unlike all the others it utilises a prototype manual data input (MDI) control system. In this case the machine has been designed with the intention that programming (as well as proving of programmes as with traditional CNC) may if necessary be carried out at the machine itself, during the production of the first of a batch. This is achieved via the use of a microcomputer in the machine's control cabinet. At the moment, each time a new component is made the computer's memory is wiped clean and the previous programme is lost, but it is intended in the near future to add on a device which records the programme for future use on a magnetic cassette tape. With this machine office programming is eliminated, and proving is effectively carried out during the actual programming.

From this description one might presume it possible to predict the sorts of tasks employees should carry out, and the way the tasks would be divided amongst various functional groups. However, this is a purely technical description of the innovations, and the way CNC is actually applied depends upon certain non-technical considerations.

The Interested Parties

From the beginning, senior management (4) at the plant offered no firm guidelines on the ways in which tasks were to be allocated, and it seems that the present senior

management team - and for our purposes the relevant actors are the managing director, the manufacturing director, and more recently the personnel manager - have inherited a set of working practices which they themselves would not have chosen. Exactly why senior managers have failed to dictate events on the shopfloor remains uncertain, although several long-serving staff did express their private views that influence over internal events was, and still is, largely in the hands of the middle management team - their ideas often being at odds with those of the directors. Some conflict, expressed in the form of complaints about "directors who don't know the machine tool industry", or about "supervisors who can't adapt to change", was occasionally expressed, and indeed one might expect this sort of rift when we note that virtually all the middle managers are long-serving employees, often having risen from the shopfloor and mostly at the peak of their careers (many reaching retirement age within the next ten years or so), while the present directors are the latest of several senior management teams (5). Thus to understand the management input to current practices we have to look further down the organisational hierarchy to the middle managers and foremen.

In the absence of any firm management guidelines, the union (6) could easily assure that operators on the new machinery were drawn from existing ranks (some machinists were keen to work with the new technology) and that only skilled labour was used. Union concern that only skilled machinists should operate the machinery is not, however,

primarily a concern with the tasks people carry out. Rather, it is first and foremost an attempt to ensure that conventional job gradings are continued. As we have already explained, in this plant skill refers to pay and status, as well as to the nature and complexity of tasks, and although the two meanings are not unconnected (it is easier to justify skilled status when the work really is skilled) it is the former which most concerns union officials (7). The important point here is that skilled labour (in both senses) is used, and this has important consequences for the way CNC is utilised (8). As with other skilled operators in the plant, the CNC operators have, on conventional machines, been accustomed to carrying out both setting and operating.

There are now five programmers, two of them trainees. The last three recruits were internally trained. Most are young, with at least some career ambitions. Technical apprenticeships are being undertaken by the two trainees, which are intended to ensure that the programmer gains some experience of machining on the shopfloor as well as programming. They are not, however, recruited from the same source as the machine operators, with a different status in the company, being represented by a different union, wearing white coats rather than blue overalls, and so on (9). Because of the nature of the work, a close relationship with shopfloor operators is inevitable, but these status differences - many of them obvious even to the casual observer - serve only to emphasise that a close relationship is not necessarily a congenial relationship.

The final group of actors with a stake in the outcome of the new technology "drama" were the planners. (In fact, of course, some other groups were involved, but in much more indirect ways.) The planners are the office staff who provide the documentation necessary for manufacture. A major aspect of their work is the provision of planning sheets, which contain information on methods of manufacture (in the case of machining, the type and order of cuts, and so on). As one might guess, shopfloor machinists often refer to them as incompetent "office wallahs" whose lack of shopfloor experience renders their planning instructions highly suspect and subject to correction, increasing the workload of the machinist, and representing one aspect of the way in which "management rely on us to get the work out". Today the planner's work overlaps with that of the programmer too, and one might suspect a similar - if less overt - schism between the two groups, the programmers complaining that their lack of programming experience means their planning sheets are not always appropriate to the needs of CNC machining. There are about six planners, and in the office they contrast sharply with the programmers by their much older age and more sedate behaviour. In fact as a group, the programmers are probably the youngest employees in the firm, as well as being the newest, and in the Manufacturing Facilities Office their age contrasts with all the other groups of office staff too (10).

This outline of the character of the various interested parties should serve to set the scene for the discussion of

the evolution of real working practices.

Negotiation of Working Practices

We have already mentioned that the work of the process planner is often questioned by the operator on the shopfloor. With the transfer to computer control the planner's work now goes first to the programmer, whose programme should be written according to the way the planner has decided the job should be done. The planner also decides which jobs are suitable for production on CNC machines - taking into account the size and shape of the component, batch size, and so on. On both these counts, programmers are increasingly attempting to usurp the role of the planner, claiming that they are in a better position to understand the capabilities of modern CNC equipment. A few years ago, according to the programmers, the process planners would not allow programmers any say in planning, but this is now changing, and "...we often decide something is not possible and get it changed to our requirements". Programmers are also encroaching upon the traditional role of the jig and tool draughtsman. When special tools are needed "...we design and draw tools ourselves rather than getting the jig and tool draughtsman to draw them". Thus the present boundaries between these various office functions are the subject of continual renegotiation with each new piece of work (11).

There is a similar negotiation and renegotiation of tasks between programmers and CNC operators on the shopfloor, and it is this aspect of the change to CNC on which we will

concentrate. But dealing with official management policy first - or rather the lack of it - there are no laid down rules for programmers and operators to follow. On introduction of the machinery management did give the usual assurances about no redundancies through use of the new technology (12), but neglected to give directions on task allocations. The division of labour has been discussed in meetings between management and worker representatives, but no clear-cut divisions have been settled. (The present senior management team do have plans for the near future, and these will be discussed below, but they play no part in current practices.)

The operators of the CNC machines, as mentioned above, are all skilled machinists. They have, however, each spent only one week in formal training for operating CNC machines. The programmers, on the other hand, have served or are serving lengthy technical apprenticeships geared to the needs of computer control. It thus came as a surprise to learn that operators were getting themselves involved in more than just setting and minding the machines, and eight out of the nine operators were questioned in detail to find out exactly what they were doing. Of these eight, three were in fact carrying out at least some of their own programming, and another four were becoming involved in tape editing (i.e., modifying the programmes which come from the office).

When programmes have been produced in the office, they have to be brought onto the shopfloor and "proved" at the machine tool itself, and here there is some disagreement

over whose task it is to do this editing. Also, even after the tape is proved with the first of a batch being satisfactory, operators may still wish to make minor adjustments to the programme - for instance to take account of variations in material quality. The programmers would also wish to question the operator's right to do this. They insist that editing is their own domain, and a battle for control over this important function is carried on. The conflict is symbolised by a key on the control cabinet of each CNC machine, which locks and unlocks the tape editing facility. The programmers would like to take this key away after having proved their own programmes, and to keep full control over use of the machine's control panel. So far, however, operators have managed to keep keys on the shopfloor. Keys never leave the control cabinets, and the real division of tasks, according to one CNC operator, depends on "...the circumstances of the job in question, the availability of programmers, and also on personal preferences". In other words there is an ad hoc renegotiation of task divisions with each new job, but operators tend to have the upper hand in these negotiations, and in most instances choose for themselves. After four years operator involvement in editing, this practice is well established, and one could imagine the difficulties in any attempt to change the situation along the lines the programmers advocate.

In a nearby firm which utilises exactly the same CNC turning machines as are used here, tasks are divided not only between programmer and operator, but also between setter and

operator, and keys are taken from the control cabinets after proving has been carried out. Here the setter's work is very simple - tooling is pre-set - and the operator's work is even more deskilled, consisting only of loading/unloading, pressing the on-off switch, and some routine inspection. Information on these practices came first from one of the operators, who expressed disapproval. Interestingly enough it was also mentioned by a programmer as an example of how CNC should be used (13).

Returning to our case study firm, of the three operators who do some programming, one works on a manual data input lathe which is designed for operator programming, and we will come back to it later. The other two work on machining centres, which are designed for office programming. One of these operators has worked on his CNC machining centre for four years, and has more or less taught himself how to programme. Starting from an engineering drawing, he programmes the machine using the tape editing facility. This is not the ideal way to programme, and requires some ingenuity, although the operators made it clear that this was not a totally exceptional case, and that machinists in other plants had picked up the same skills. This operator has helped teach a younger, recently apprenticed, operator this skill (even today's machinists are not formally taught programming) and the two of them now do the programming for over half the components they make (14). Management have tacitly recognised the abilities of these operators, and occasionally express their admiration of the work done. The programmers

also seem to have accepted an operator input to programming in these cases, and speak of the much-needed lightening of their own workload (15).

Although task divisions are left mainly to the programmers and operators to sort out among themselves, it is no doubt helpful to have some moral support from other groups. The foremen and superintendents on the shopfloor are particularly important here, and probably because they were themselves machinists in the past, they fully sympathise with the arguments of the operators. Their justification for taking up a position supportive of the operators is expressed in terms of technical necessities - for instance programmers do not always produce the tapes quickly enough to keep the machines busy - but also in terms of a "...waste of operator's skills if they just stand and watch". Middle management and foremen thus appeared to express a romantic attachment to what could be considered "out-dated" values of craftsmanship which merely present obstacles to the "logical" application of technology, and certainly they view the threat to the existence of the skilled machinist with some misgivings. However, their wish that the skills of machinists should not be degraded cannot automatically be written off as uneconomic, and when we come to discuss the arguments surrounding the choice of machine control systems we shall see that there is a healthy economic argument in favour of keeping and extending skills.

All in all, it may be an exaggeration to call the shopfloor a hostile environment for programmers, and any conflict

observed tended to come in the form of snubs or cynical comments. But there can be no doubt that the physical location of the editing facilities on the shopfloor gave the machinists a decided advantage in any dispute over who was to carry out editing (and sometimes programming) at the machine. Not only were most people on the shopfloor supportive of machinists (shop stewards, foremen, superintendents, other machinists), but the shopfloor in this firm was generally still very much the domain of the blue collar worker.

Rationales

In their battle for control, machinists and programmers used economic and technical arguments to justify their own stances. No doubt not all the arguments used were uncovered, but some of the basic ones can be summarised as follows:-

Programmers

1. The machines have been designed for separate programming and operating.
2. Programmers are trained to prove tapes, and have a better technical ability.
3. Machinists might be competent on conventional machines but different methods are necessary for CNC. Machinists tend to use out of date methods.
4. Having written the programme, we have the best knowledge of the component being machined.

Operators

1. Machine design allows for operator input.
2. Skilled machinists have the best knowledge of actual machining, and thus should be involved in methods by editing tapes.
3. There is no substitute for shopfloor experience, and new methods can easily be learned.
4. We have to operate the machines; we need to know the workpiece too. Besides, for many jobs, programming at the machine is possible.

5. Programmers need to see the results of their efforts in the form of finished work in order to learn their job better.

5. If programmers did all this then operators would spend a great deal of time idly standing by. Besides, operator editing means that programmers have more time to spend on their proper task - producing tapes in the office.

6. After proving, the key should be removed to prevent tampering because machining methods have been expertly established.

6. The key must be left at all times so that adjustments can be made to take account of variations in material quality, issue of oversized material, etc.

All this "technical knowledge" no doubt carries some logic in its own right. However, the logical argument one chooses is dependent on an underlying political position. The desire for control obviously rests on more than a neutral consideration of technical efficacy, and occasionally the underlying motives would be indicated. For example, the programmers' section leader claimed that:

"....CNC gives management more control as to what goes on on the machine.... once programming is done there should be no way anyone could mess around with it....CNC was designed in the first place because semi-skilled labour is cheaper....Management should decide exactly what the operator's tasks are, and give us full authority for the programmes."

Programmers identify themselves as the new group which should be taking control of manufacturing processes, and obviously feel frustrated - perhaps even threatened - when operators take on what programmers see as their legitimate roles. Having recognised the control implications associated with their dominance, one might expect management to support

programmers in their struggle to take control out of the hands of shopfloor operators. However, at middle management level the support has gone the other way. Senior managers are somewhat more sympathetic to their case, as we shall see below, but if any directives have been given on the issue, they have so far failed to filter through to where it counts.

Looking for obvious "rational" motives, the discovery of simple instrumental reasons for the operator's desire to control the work process was expected. We come back to pay later, but suffice it to say for the moment that operator control of programming or editing offered no advantages whatsoever in terms of increasing bonus pay. Rather it seems that a highly skilled and intelligent workforce simply did not wish to hand over the control to which they are accustomed, and accordingly their personal preferences were expressed in terms of "maintenance of self respect", "using skills", and "gaining work satisfaction". According to one operator, CNC machines "...cut your arms off, make you blind, make you deaf, and cut off your sense of feel.... These machines deskill us - being involved in programming brings some interest back". And in the words of another, "...we still use our skill, and still have our self respectIf they separated programming and operating I would seriously consider finding another occupation". Indeed, it was the operator who was least interested in extending his work beyond machine minding who was most instrumental:

"They're paid to programme, we're paid to operate, and the two should be kept separate until they want to pay me more

for the job. No tape, no job....Management will let you start doing programming, but they won't pay you for it." (16)

Operator "strategies" for control, succesful as they have been so far, have hardly been coordinated or organised. In fact some operators asked the researcher how others operated their machines. The machine shop is laid out functionally, meaning that turning machines and machining centres were on different sides of the machine shop, and contact between CNC operators from the turning and milling sections was particularly limited. One presumes that only in the case of an attack on current working practices would the two come together to hammer out a coordinated strategy. However, the stewards had been known to prevent programmers from tampering with machine control cabinets when requested to by individual operators, and this was sufficient for programmers to complain that "...there is too much resistance on the shopfloor".

Technical Constraints

So far we have not discussed any constraints on working practices imposed by the hardware employed. But these obviously do exist, and do place some limits on the amount of control an operator can exert. This point is best displayed by contrasting the three types of CNC machine used - i.e., the manual data input lathe, the machining centres, and the turning machines. Taking the MDI lathe first, the operator does all programming, setting and operating (17);

on the machining centres, operators are always involved in tape proving, but do only about two thirds of the programming; and on the turning machines operators rarely do programming, and sometimes the programmers prove their own tapes. The difference between the three are tied up with design of the machine tools - i.e., some facilitate shopfloor programming far better than others - though of course the firm is not simply at the mercy of any particular designers: the firm can choose between different machines and machine control systems. Before looking at the processes involved in choosing between CNC systems, however, and to emphasise the fact that this section on use of technology is not dealing only with peripheral or unimportant work practices which are "largely determined", let us make a contrast. First recall the operator on the machining centre who carries out all his own tape proving, and the majority of his own programming, then compare this practice with the following quote from the capital justification for the very same machining centre, written by a production engineer, and representing the expectations placed on the hardware:

"The further use of CNC in the machine shop will reduce the need for operator skill. With the present shortage of skilled operators, this is particularly important. Further, by taking the control of the machining away from the operator a more consistent performance will result."

Shopfloor Inputs to Technical Design

The quote from the capital justification above should now be contrasted with the following comment from another capital justification for a very similar CNC machining centre, but written by a different production engineer. Here, among the list of advantages of its control system is: "Far easier to programme on the shopfloor". (This particular machine is yet to be sanctioned by the directors, but the production engineer who wrote the justification suggested it may soon be given the go-ahead.) This justification of basically similar machines on opposite grounds reflects the flexibility of some modern CNC equipment, the choice of hardware not determining tasks. In fact if we include human tasks in our definition of technology, we must recognise the relevant actors in the firm as playing an important part in actually designing that technology. This is not simply to say that tasks can be combined in different ways, which is really job enlargement, but that the tasks themselves are still to be determined, even given all the hardware. If operators do some tape proving, or if programmers design and draw their own tools, all that happens is a transfer of tasks from one occupational group to another - the tasks remain the same. However, when operators programme at the machine itself, the tasks themselves change, and we are talking about a redefinition of technology. Programming at the machine tool itself means using equipment ostensibly intended only for editing, and by-passing the programming facilities in the office. Operator programming, then, is a

profoundly different "way of doing" something, representing a profoundly different technology. Thus when the two production engineers are considering the same machining centre, they may in an important way be conceptualising different technologies. (Another example of technology being redefined by real working practices occurs when operators use the manual override on the older NC machines. This facility is intended only for exceptional use, and its everyday use effectively means that NC machining technology has become conventional machining technology.)

The contrast between programmer-programming and operator-programming is also the contrast between what we might call conventional CNC and manual data input (MDI) CNC. By striving to become involved in programming through taking advantage of editing facilities, operators have implicitly been creating an MDI technology, and although existing hardware places limits on the development of this practice, the achievements of operators could hardly be trivialised. But there are limits, especially on the turning machines, and thus we must look at the choice of technology as a constraint on working practices.

Choice of Machine Tools

Not only production engineers are involved in choosing equipment. What happens is that in policy meetings involving the manufacturing director and various others - the head of Manufacturing Facilities, the machining superintendent, a production engineer, and sometimes the managing director

(participation depends on the size and nature of the capital expenditure) it is decided that a new machine is needed to do a particular job. Brochures and other information are collected, and the various engineers and managers decide between them the machine they think will be most suitable. A capital justification is drawn up by a production engineer, and this then goes for sanction to the directors. One production engineer stated that:

"With justifications, we look at machines against the type of work anticipated, then justify them solely on the grounds of costs - payback periods and so on.... It's very important to get the right man for the job, otherwise production suffers. But we get the machine first, then the operator....If we don't have the right one we'll go outside to find him."

This implies that the firm buys the machinery, then deals with the social consequences later, and certainly justifications make very dry reading, referring rarely to the character of employees. However, the quotes from the justifications stated above do show some concern with the type of work machines might create, and certainly before the capital justifications are written there is a good deal of informal discussion and deliberation, giving grounds for suspicion that formal justifications could be "post hoc" technical rationalisations which simply play down the social and political considerations which go into them. If and when more MDI machines become available, then we may expect a strong push by middle management towards this technology, but not necessarily to see it reflected in formal documents

as a social choice.

Certainly management and engineers at all levels are beginning to recognise that there is a choice to be made. A production engineer sums it up: "The firm has to go one of two ways. We can either retain skill on the shopfloor and have manual data input, or transfer skill into here with more tape control machines."

Machine Tool Design

But given all this, availability of MDI is still a problem which is bound to place limits on management choices, and it is thus important for us to examine machine tool design at the supplying firms in order to fully understand the way technology and skills might develop within this firm. An empirical examination of machine tool design along the lines of this research would probably prove highly fruitful - for if it is necessary to understand the social context of application to understand technology, it is doubtless also necessary to understand the social context of research and development. This is outside the scope of this research project, but fortunately we can refer to some work currently being carried out at the Machine Tool Division's laboratories at the University of Manchester Institute of Science and Technology, which is directly relevant (18).

Here an MDI lathe has already been successfully developed which is similar to the prototype lathe in our case study firm. The nature of jobs with this system have been considered during its design, and the result is an "interactive"

microcomputer control which allows the operator to programme the machine during the production of the first of a batch. It is assumed that a conventionally-skilled machinist will be the operator, as is often the case in small and medium-batch production (19). Professor Rosenbrock and others, from the Institute and elsewhere, are now considering a research programme in which a whole flexible manufacturing system (including a robot, an NC milling machine and an NC lathe) will be designed to allow for operator programming on the shopfloor. It will both take advantage of the machinist's existing metal-cutting skills, and extend his skills to include computer programming. At the same time as being developed with commercial applications in mind, the opportunity is to be taken to study the ways in which work designs are "built in" to the technology, and how these can be influenced by social scientists or other interested parties at the development stage of the technology.

The results of this research should give valuable insights into the development of MDI, and hopefully also to the social forces behind the direction which CNC technology is taking and will take in the future. Presently machine shops such as our case study firm's are in the position where their future technological development is uncertain. Much depends on the direction of machine tool design, which is largely in the hands of others (20).

Future Directions of the Firm

Senior management have so far had little direct influence on the development of working practice traditions (21). Yet since their arrival they have been formulating ideas on where the company should go with regard to machining technology. Basically, the manufacturing director would like to create a new grade of "section leaders" (or "leading hands") who would be responsible for groups of CNC machines. Rather than being a chargehand, the section leader would be a "supergrade" of machinist - his skills and responsibilities being recognised by a new pay grade. Being the technical expert for a group of machines, he would be responsible for tape proving, and assuring machines were correctly set, production runs smooth, and so on. This would "...release the programmer from the shopfloor so that he could concentrate on producing tapes" (tape shortages are currently a major problem) at the same time as "...deskilling the work of the operator", who would now be basically a machine minder. The source of section leaders would be from among those skilled machinists who have taught themselves some programming and are obviously competent at the control panel: "When you get a worker who tells the programmer how to do his job, you want to make better use of his abilities". With the shiftworking which is envisaged, and with the expansion of CNC equipment which should come shortly, it should be possible to use all or most of the present CNC operators as section leaders.

The machining superintendent pointed out that the

section leader ideas already operate to some extent informally. In particular, both training and advice are given to newer CNC operators by the more experienced ones. However, initial moves to formalise and extend the idea have so far been met with resistance by the union, which is "against the creation of an elite", and implementation is particularly difficult in the current context of short-time working and redundancies.

One million pounds is to be made available for new machinery by the American owners this year - specifically for equipment necessary to produce one of their domestic products for the European market. Much of this new machinery is to be CNC, and will presumably provide some opportunities for reorganisation. What is likely to happen is difficult to say. The positions of the various groups have been outlined, and we can expect some disagreements, but so far differences have not been expressed in overt ways. It is tempting to predict, and it is tempting to urge particular directions to be taken, but neither will be attempted here. Suffice it to have shown that there are choices to be made, and the mechanisms through which those choices operate.

Shifts and Payment

Two major aspects of work organisation shown to be important in some of the other case studies - shifts and payment systems - have not been discussed. Shifts have not been discussed because none are worked. But it is worth mentioning here that many of the CNC machines were justified

on the basis of shiftworking, and that their payback periods are greatly increased because of this underutilisation. This point is, of course, significant in management's desire to introduce shiftwork again in the future, and as such represents one way in which the technology may affect the working patterns of shopfloor workers.

The payment system has not been discussed because presently it does not influence, and is not influenced by, the CNC technology. A bonus system does operate, and one could expect this to affect the way operators work the machines. Certainly, on hearing of operators insisting on keeping keys to control panels, I half-expected to see operators using this as an opportunity to adjust speeds and feeds to higher rates than the time-study man believed were being used. This is not the case. Because of the current shortage of work for CNC, and also because of the lack of planned times for jobs on CNC, the tendency is for operators to be given a "planned" time (for the purposes of bonus calculations) for the actual time it takes to do the job, assuring maximum bonus is recorded, regardless of the work done (22). The payment system does, however, become important in our discussion of the new shop scheduling system, and a full explanation of its mechanics will thus be found in the next chapter.

CHAPTER TWELVE

THE MACHINE TOOL MANUFACTURER - SHOP SCHEDULING

Introduction

Chapter 11 has described the social and political aspects of the new production machinery being introduced in this firm. This chapter examines the attempted computerisation of the system of progress chasing.

As we shall see, the new system of organising and controlling the flow of work around the shopfloor had implications wider than the effect on the work of the progress clerks, and in particular cannot be properly understood apart from the payment system and the whole system of production control. However, my interest in shop scheduling began with the changing role of the progress clerks, and we will begin this section with a discussion of their work.

The Progress Chaser

The progress clerk, or "chaser", has until recently played a role in the firm which has hardly changed for decades. Some of the chasers have been with the firm for most of their working lives, now nearing retirement age, and they have seen no basic changes until the current one. In the summer of 1980 there were nine progress chasers. One retired but was not replaced, so that in October when the new system was introduced there were eight. Their union is the AUEW, and they have a section steward to represent them. They share one office in the centre of the shopfloor, and

apart from the fact that they have a desk each, they are barely distinguishable from other shopfloor workers. In this respect they stand apart from the other technical and office workers in the company, whose different status is emphasised by the wearing of white coats, being members of a different trade union (TASS), and so on (1). The progress chasers' pay grade is one down on skilled machinists - they are recognised as semi-skilled workers. Of the eight progress clerks one is a woman, who keeps the records in order, and apart from the tea ladies who venture into the shop twice a day, she is the only woman one is likely to see on the shopfloor. There is a supervisor in charge of these eight progress clerks, and he has an adjacent office. The door between the two offices is never closed, and the supervisor is constantly interrupted by both the chasers who come with a host of problems, and the foremen from the various sections of the shop who want to know where this or that piece of work is, and so on.

The division of labour among progress chasers was previously based on end products - meaning that each chaser would be responsible for assuring that all parts necessary for a particular machine, or group of machines, were on schedule. This would involve checking that the right parts were in stock, or at least on order in the purchasing department, and that "made-in" items were on schedule for completion by the date they were due to be assembled. Most time was spent chasing made-in items, which generally have to travel around at least several different sections of the

machine shop for various functions to be performed on them - e.g., turning, milling, boring, drilling, tapping, etc. A record was kept in the office of the movements of the various components, such that a glance would tell one the location of the items necessary to build any particular machine. All this meant that the progress chasers had a detailed knowledge of certain machines, and a detailed knowledge of the whole machine shop, both being necessary for them to perform their work properly.

Problems with the Progress System

One of the major problems with this system, and in fact a major impetus to changing the system, was that because work was allocated by machine, the progress clerks would chase their own parts around different sections of the shop without due regard to the needs of other progress chasers. Thus the foremen responsible for the different sections of the shop (milling, turning, etc.) would be under pressure from several different progress chasers demanding that their own parts be made and moved on quickly. There would thus be a tendency for work which was not really required in the near future to be dealt with before more urgent requirements, and this led to shortages of parts for the machine assemblers. This problem is an old one which has been recognised by the company for many years. For instance a company document written over ten years ago comments that "...of 50 components in a sub-assembly, 5 would not be available when required". A great deal of time would thus be spent

"fire fighting" - with foremen, individual fitters and superintendents as well as progress clerks chasing urgently required parts. Apart from machines not being built on schedule there would often be an ad hoc splitting of batches, and a tendency to switch workers more frequently from one job to another - the resulting inefficiencies being considerable.

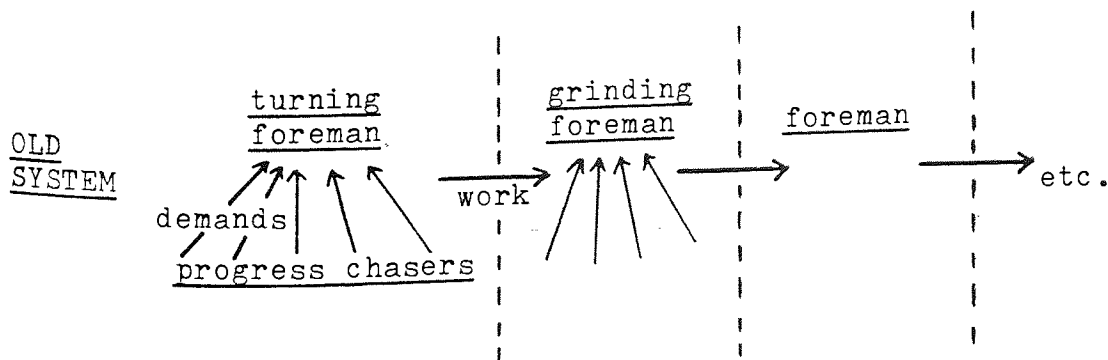
An attempt to remedy the situation was the introduction of a priority list system. Each section foreman would have a list of work which was top priority. These jobs were derived from shortages at the fitting stage, and were placed on the lists by the progress clerks, who liaised closely with the fitting foremen. However, the effectiveness of this system soon declined. As one foreman explained, "...it was alright when it first started but after a bit, and if the shop had got a big workload on...in next to no time you've got sheets and sheets, so it doesn't mean a thing" - the progress clerks were beginning to put everything they wanted onto the sheets, regardless of urgency. Thus a "super-priority" system was attempted - green stamps being placed next to those items which really were urgent. According to the same foreman: "That went alright for a bit until these lads realised that by putting a green stamp on they got it quick, so they were putting bloody green stamps on the lot!" Two green stamps were tried next, and later two separate lists were used - one for "really urgent" fitting requirements. The latter system was used until the recent change to shop scheduling, and has worked reasonably well.

This was partly because of a better understanding between fitting, progress and machining sections, but also because the recent decline in output meant a smaller number of urgent fitting requirements.

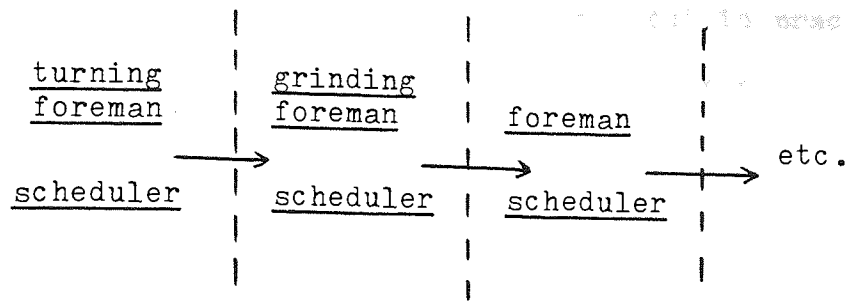
The problem described above is a part of the more general problem of high levels of work in progress, which has obvious financial implications, and is the central motive behind the new scheduling system. It is hoped that the new system will allow the turning over of stock and work in progress twice a year instead of once.

Shop Scheduling

Basically, the new system of shop scheduling is a transfer from a division of labour by group of products to a division of labour by geographical area on the shofloor. Now, instead of being responsible for a group of machines, the progress clerks (now known as "shop schedulers") are responsible for a particular section of the shop (e.g., grinding and gear cutting, the heavy bays, the turning section, etc.). For most sections there is now one foreman and one shop scheduler, and they are supposed to work together in assuring that the right job is done at the right time:-



NEW
SYSTEM



Priorities, instead of being decided by fitting foremen and progress chasers, are now given on computer print-outs. The necessary information, taken from work tickets, is collected by the production control staff and fed into a computer which is programmed to produce all the instructions necessary for jobs to be properly scheduled. The information comes back to the schedulers once a week in the form of computer print-outs, called "work centre schedules". The foremen also receive copies. These schedules give a priority rating in terms of figures for each component or workpiece which is to pass through that particular work centre in the near future - the lower the figure the higher the priority. The schedulers explained that "as a rule of thumb" the minus figures are urgent, those below one are important, and those above one can wait. Each piece of work carries with it a "travel document", containing machining instructions, batch quantity, etc., and these are collected in boxes at each section of the shop as and when work arrives after previous operations. The scheduler can now simply arrange these in order according to the priority rating given on the work centre schedules, and the foreman can ensure that the urgent work is done first.

As we shall see, the system has not worked out in practice in such a clean and simple way, and to some extent old methods are still relied upon, but the schedulers have now experienced the new system sufficiently to form some opinions on it. Before looking at the problems of the new scheduling system, and before examining its wider ramifications (assuming that its problems are not insurmountable) we shall see what these opinions are.

From Progress Chaser to Shop Scheduler

The schedulers are unanimous in their opinions on the new computerised system. It is far from preferable to the old. Instead of taking responsibility for a whole machine or group of machines, and chasing every part necessary for its production, the scheduler simply receives a list of priorities for a particular section of the machine shop, and sees that the coded instructions from the computer are fulfilled.

With the old system, "...you become a part of that machine....you're doing something constructive. When you see a machine being built you're achieving something", and "...I could walk up a section and see from a distance what I'm looking for. I knew exactly what the parts I needed looked like and where I'd be likely to find them". With the new system, however, "...everything becomes a number on a priority basis. The new system only tells us numbers and priorities....now it's just numbers, it don't mean a thing".

The expression of production needs in terms of codes and numbers is totally new to the progress chasers, and they accept the new way of doing things only with reluctance. An often amusing, but telling, aspect of their treatment of the new system is the constant attempts to translate figures and codes into tangible events and physical objects. For instance, when one day I was following a scheduler as he went about his daily business (2) we somehow found our way into the production control department. "What's P2?" he asked one of the data processing personnel. "The P's are the buyers" came the reply. "So who's P2?" he shouted out loud. There was no reply this time, but we now went up to the buying department where he asked again: "Who's P2?". The buyers looked a little embarrassed, but one owned up to being P2. "And what number are you Sheila?" asked the scheduler as he turned to another buyer.

Other examples are the translation of code numbers into particular production machines on the shopfloor, or into components, sub-assemblies, etc. But of course it is impossible to turn all these abstract figures into physical appearances, and in the end the scheduler has to learn to deal with numbers which "don't mean a thing".

Schedulers also talked about the loss of responsibility with the new system. Previously when target dates were not met and shortages appeared during assembly, "...the fitting foreman would have someone to attack - we knew whose fault it was". But now there are likely to be several schedulers involved in the production of any particular component

(the component may have to be milled, drilled, tapped, and ground, etc.) so that "no one person is answerable".

The work is also obviously far simpler and far more tedious - the computer programme now doing the locating of work in progress as well as determining priorities and monitoring movements; and also more impersonal - "crunching numbers" is not the same as working and negotiating with the foremen (3).

All in all the transition from progress chaser to shop scheduler has been an unpleasant one, but then "...that's modernisation, isn't it?".

Problems with the Scheduling System

After seven months the scheduling system still did not work, and one had to wonder whether the "teething problems" were not really deep faults. The schedulers still relied on the old system to a large extent - exactly how we shall see later - and certainly they believed (or at least hoped) that the new system could never work: their numbers and priorities "...nine times out of ten are wrong", and one explanation was that: "...there are too many small batch parts for too many machines for this system to work. It might be OK in a car plant". In fact there are likely to be a host of reasons why the information coming from production control was inaccurate, but one of the main reasons was the poor quality of information going in. Here perhaps the major factor - and certainly the one factor which management were aware of and the schedulers acting upon - was the

way the payment system was being worked by machinists and assemblers on the shopfloor. Indeed it is difficult to understand the scheduling system at all apart from the payment system, and an explanation of its workings may be useful.

Until 1973 the firm operated a piecework system, requiring twelve ratefixers to establish and negotiate times (4). Between 1973 and 1976 there was a simple hourly rate, with no bonuses at all. Then from the end of 1976 a group bonus scheme was devised. This still operates today. It is based on the work done by operators and fitters, but most other employees do benefit by receiving percentages of the bonus earned - for instance shop schedulers receive 50% of the bonus achieved. Given the "group" nature of bonus pay, it may seem a little strange that bonus calculations are only indirectly related to overall output - individual operations still being measured as under the old piecework system - but this is the case, and exactly how it operates is as follows:-

A "performance" is calculated each month by dividing total issued time by total clocked time (these "total" times are those for direct labour only - i.e., operators and fitters):

$$\text{Performance} = \frac{\text{Issued time}}{\text{Clocked time}} \times 100\%$$

The bonus payment threshold is 63%, and for every percentage point above that a bonus of £1 per week is paid - up to a

maximum of £15. "Issued time" is the time which comes from the planner's office with the work ticket, and "clocked time" is time worked (taken from clocking-in cards). Thus the nearer workers get to issued times, the higher the performance.

Many of the issued times have been established by time and motion studies, or by agreements between ratefixers and operators. But for the last seven years or so no proper "ratefixing" has been done, and thus some of the issued times are just planners' estimates. In these cases any extra time taken to do the job is automatically given a "variance code", and the total time recorded counts as the issued time (i.e., the planned time) regardless of the real time taken. (Variance codes represent excuses for spending more time than estimated for particular jobs - e.g., faulty castings, incorrect drawings, machine breakdown, etc. - and there are over a hundred of these.) However, most of the variance codes are excluded from bonus calculations. The clocked time used for calculations is also reduced accordingly so that there is no effect on the calculation. Operators, of course, often try to convince ratefixers that the extra time they took falls into one of the bonus paying variance categories, and no longer being involved in establishing times on the shopfloor, the ratefixers are at a disadvantage in negotiating variance codes and times. Operators are thus tending to get what they want written into these variances more frequently than one would normally expect. Management have recognised this as a problem, and intend to give the

foremen the responsibility of adding variance codes and times to work tickets, since foremen "know what is really going on" (5).

Also the code numbers used are to be reduced in number to six, in line with the coding system in operation in the US firms. Thus when information from the work tickets is compiled and sorted by a central computer, the US parent company will be able to see at a glance exactly where inefficiencies lie. For instance, if the variance code representing machine breakdown is frequently used, this may suggest the need for more preventive maintenance, etc.

At the same time as individual operators and fitters seek to increase the recorded "issued time" going into the bonus calculation, the stewards somehow manage to gather and record information on the development of bonus pay for the month. When the ceiling of £15 is reached some work tickets are "banked", to be submitted for the following month. In this way workers can control their bonus pay from month to month (6), and have in fact managed to achieve the full £15 for several months running now. In fact they hope that management may now raise the bonus ceiling to allow them to earn more.

It is precisely this "kitty" of work tickets which leads to inaccurate information being fed into the computer in production control - for information from the same tickets is being used by production control to tell the computer when a particular piece of work is complete, and when it has moved onto the next operation. Thus the work centre sched-

ules coming back from production control are bound to be inaccurate and out of date, and the schedulers have to rely on the old system to "botch up" the new.

Botching up the System

With the old progress system, the woman who dealt with records always used inspection tickets (which are blue) rather than work tickets (which are white) to update information in the progress books. She has continued to do this throughout the implementation of the new system. The blue tickets are signed by inspectors immediately on satisfactory completion of any particular operation, and are left in boxes at work stations. Every morning these are collected by the progress clerk, and entered into the progress books, so that the exact position of work in progress can be seen for each machine. Then each week when the work centre schedules arrive from production control they are "updated" from the information gathered by the old manual recording method. Each scheduler has to spend at least several hours every Thursday carrying ou this laborious botching up.

Schedulers also maintain the old system to some extent through habit - they still tend to "...keep an eye out for our old machines", and when parts go missing the easiest and quickest way of finding them is still through the scheduler's tacit knowledge. However, these skills now being officially redundant, the schedulers complain that they are gradually losing their old habits, and wonder what will happen if the system fails to work before their old abilities

are forgotten altogether.

An explicit recognition that the scheduling system was failing was indicated by management in December 1980 when two of the schedulers were allocated the full-time task of dealing with fitting shortages. Liaising with the fitting foremen, they compile "critical shortages" lists, and pass them to the appropriate schedulers who ensure they are given priority treatment at the work stations - a familiar practice!

One wonders why production control do not use the blue tickets in favour of the white tickets as their information input, but the only explanation gained was that "...the blue tickets are going to be phased out in the near future, so we might as well get used to the white ones". Using white tickets certainly means standardising practice in line with the US system, but one cannot help seeking a more convincing explanation than bureaucratic tidiness (7).

Despite all this, scheduling is going ahead, and one must ask what will happen to the scheduler presuming that the system is made to work - in particular by making the bonus system work once again. The schedulers already recognise the system's potential for making them "replaceable": "...anybody can do the new job". But also, as one scheduler put it: "...they might want to put us on the dole queue - eliminate progress men altogether". Schedulers have been told that they will take on the new tasks of allocating work to machine operators, recording it when completed,

and handing out more work, etc. However, the schedulers feel that the foreman is the person with the best knowledge of the capabilities of operators, and thus best able to decide who should get which job. Thus they see this as possibly being a temporary measure, to be phased out as and when foremen are persuaded to become their own schedulers.

But whether or not the scheduler (or anyone else) is employed for this task, we can now see the bringing together of the progress function and the payment system at the point of production, the monitoring and control of both now being in the hands of a foreman with greatly enlarged responsibilities. Exactly how these new responsibilities will be dealt with is to be seen.

Management Control

Taken together, the changes in the payment system and in progress reporting represent an attempt by management to gain control over what goes on on the shopfloor. In particular, by making foremen responsible for completing variance codings on work tickets, and by eliminating the progress chaser as such, management control over production becomes more direct through the management hierarchy, rather than through a progress system and through industrial engineering. It is only in this context that the new computerised shop scheduling system can be understood. It is not simply a new technology which has come along and affected the workplace. It was actually introduced and used for control purposes - it is in fact a control technology.

Of course, it is not easy to refer to this need for control either in a straightforward political sense, or as a simple technical necessity - it is of course both: the economic and technical need for better control was obvious (high levels of work in progress, etc.), but the actual form the new system takes is dependent on a host of political factors.

Senior managers at the plant have been responsible for installing the new control systems, and if and when the systems work the advantages to them will be great - control over production would be more directly in their hands. However, this control is first dependent on getting the workforce to give up its own control of the bonus payments, with regard to both variance codings and work ticket kitties. This is hardly a straightforward task. Also, it would mean more generally that the performances of middle managers and foremen could be measured "objectively" by reference to production figures - a situation one might expect middle managers to be reluctant to accept. Thus achievement of control is highly problematic, and the outcome in terms of working systems are by no means given.

The efficient functioning of the systems also means that in turn the US parent company can more easily measure the performance of this UK subsidiary, and can even have a breakdown of figures which points out to them exactly where any "inefficiencies" lie. In particular, the rationalisation of the variance coding system can probably be seen as part of the US owners' attempts to do their own detailed financial monitoring, especially when placed in the context

of a more general imposition of their whole costing system. Thus the direction the control technology takes must now also be seen in the light of the needs of the American owners - and one might expect their impact to become more apparent over the next two or three years.

In the context of what was said about the differences between senior management and middle management at the plant, one can perhaps understand the attempts by senior managers to gain more control. Similarly, in the context of the circumstances in which the Americans took over this company (falling sales, recession in machine tools, etc.) one can understand why the Americans wish to rationalise, and to control that rationalisation. Access was not gained to the sort of "top level" information which would allow a thorough analysis of the motives of the most senior managers, and thus "corporate strategies" must remain largely unexplained. We have shown, however, that the implementation of new means of control are highly problematic, being dependent on, and influenced by, the existing informal control systems. One must understand these existing systems in order to properly understand motives, and in order to understand eventual outcomes.

SECTION THREE
ASSESSMENT AND CONCLUSIONS

CHAPTER THIRTEEN

CONCLUSIONS: THE POLITICS OF TECHNICAL CHANGE

Introduction

The case studies invariably show that managers, engineers and workers become involved in orienting the "impact" of new technology in particular directions, and that there are conflicts of interests, occasionally expressed openly, between the various interested parties - between managers and workers, between different groups of workers, and also between different individual managers or groups of managers. Although the resolution of these conflicts occurs largely through informal channels, processes of social choice and political negotiation are clearly in evidence, and are shown to have a profound effect on the nature of technical change in each firm. Before discussing the social and political dimensions, however, it is worth pointing out how the case studies shed some light on the practical role of technical and efficiency aspects, since these are frequently assumed to be the major, if not the sole, considerations in technical change. The case studies show how the significance of "efficiency" may in fact be other than is normally assumed.

Efficiency: Objective Measure or Ideological Justification?

The first point to be made about "efficiency", "product quality", "productivity", etc., is that these, generally unquestioned, indicators of technological success are difficult to measure with any degree of accuracy, and in any case

are rarely measured in sufficient detail to determine the exact economic advantages over any alternatives. Of course, formal (written) capital justifications may make elaborate comparisons of productivity, capital costs, payback periods, etc., between, for instance, alternative new machines. These justifications were used frequently, according to most accounts, as the basis of decisions on choice of technology in many of the case study firms. But it is probably safe to say that in no instance could it be demonstrated that in practice the new technology met the measured expectations of the production engineer who "justified" the technology, or of the machine supplier who advertised it. Besides, measures of the actual economic returns of new processes were invariably in the form of "two or three times more output per man", or "it paid for itself in about two years", rather than the pounds and pence, and hours and minutes, of the pre-implementation assessment. In practice then, there was simply no accurate measure of productivity gains or efficiency improvements (1).

The point being made here is not that new technology in general, nor even electronic control of batch production in general, can be questioned on the grounds of efficiency relative to conventional (non-automated) technology - though in some instances it can (2). Rather, the important point is that the ambiguous and imprecise nature of the measurement of performance means that choices between alternative available designs and the way they are used (the way work is organised) cannot be explained simply in terms of tech-

nical and economic advantages. Where engineers and managers do use these explanations one must remain suspicious and expect to find additional motives.

There is always more than one "best way". This does not mean that all technical designs and working practices are technically and economically feasible. But it does mean that technical and economic considerations serve only to constrain the possible options. For instance, in the case of the machine tool manufacturer, the choice between manual data input (MDI) and conventional CNC - two very different designs - was not one between technical superiority and inferiority, but between "retaining skill on the shopfloor" and "transferring skill into the office". As the case study makes clear, the availability of MDI imposes constraints on choice - if it is not available it cannot be chosen - but on purely technical and economic grounds, as far as is measurable, it is the equal of conventional CNC. Similarly, throughout the case studies, it was shown how the working practices which evolved around new equipment and processes, although not independent of technical and economic constraints, were never completely determined by them. For instance in the plating company we showed how the working practices which the platers preferred were not those intended by management (see note 9 of the case study). But it could not be shown in a straightforward way that the practices advocated by management were in any sense more efficient. To the independent observer, neither the platers' emphasis on quality nor the management's emphasis on quantity appeared

illogical with regard to performance considerations. In engineering terms they were, as far as one could see, equals.

The success of any engineering project is of course extremely difficult to measure, but when discussing the introduction of new technology into the workplace one must bear in mind the central problem of the inclusion of "labour" in any calculations. For unless one assumes the total acquiescence of workers, one must recognise that performance depends on the acceptance and proper use of new equipment by a workforce which has particular values, interests, objectives, motivations, and so on. Throughout, the case studies show how workers became involved in establishing precise working arrangements, and thus, of course, the performance - the economic returns - of the new technology. Little wonder then, that measures of efficiency are inaccurate - "labour" simply does not lend itself to measurement (or as Braverman would have it, the translation of "labour power" into "labour" is always problematic).

Given these qualifications - that measurement is inaccurate, that there is always more than "one best way", and that the acquiescence of labour cannot be assured - one must question the real role of "efficiency" arguments in technical change. In fact, what our case studies show is that arguments about the efficiency of new production technologies are often no more than scientific glosses which conceal or obscure the political considerations which have gone into decisions on technical change and work organisation. In

other words, arguments from efficiency are used by the various interest groups in order to justify, or make legitimate, choices which are essentially political, both in motivation and consequence. In the plating company, for example, management's claim that a lower quality and a higher scrap rate could be tolerated, and that improvements in total output were most important, coincided with the fact that the achievement of these ends would entail workers giving up control over the immediate production process, and allowing themselves to be subject to more rigorous pacing by the machinery. Since these latter effects had earlier been mentioned by managers as basic objectives in automation, one must question whether the performance argument played more than an ideological role.

One might expect that managers and engineers, because of their superior education and training, would always be able to win any ideological battles with workers about the efficiency of particular technologies and the working practices associated with them. Certainly at an official level it was normally the case that workers accepted management's designs - workers simply did not see the technical aspects of work as matters for their concern. It was left to managers to determine what was "efficient", and workers became involved only when areas which they did see as their legitimate concerns were affected - generally meaning, at the most, redundancy, manning levels, demarcations and payment (3). Unofficially, however, workers did become involved in important ways in technical matters - especially when it came to

the establishment of working practices - and exactly how will be discussed in detail below. The point to note here is that even though workers were at an enormous disadvantage, they did manage, when necessary, to construct their own arguments about the efficiency of their own preferred methods. The platers mentioned above are a good case in point, but even more impressive were the arguments generated by the programmers and operators in the machine tool manufacturing firm during their battle for control of the function of editing programmes.

Workers could generate arguments, however, only at the implementation stage of innovation. The design and choice of technology were thus unquestionably management prerogatives, and their technological choices were rarely considered matters for union or worker concern. And even at the implementation stage, in any case, it was managers who used economic justifications most seriously and most frequently, and it was thus generally the case that their arguments were accepted. In fact in the machine tool manufacturing firm, where workers were winning the "battle for control" over programmers, and justifying their stance in economic terms, there were no clear instructions on working practices from top management, and operators were generally supported by middle managers and foremen. If management support was strongly on the side of programmers, one might wonder how well and for how long the operators' arguments could stand up (4). Generally speaking it was managers who made most use of efficiency arguments in order to justify

intentions which were often political in nature, and certainly managers were in the best position to do so - it was, after all, part of their job. Workers' use of efficiency arguments could thus be precarious, since faith in them, in a sense, plays into management hands.

In at least two of the four more detailed case studies - in the plating company and in the rubber moulding company - one of the underlying political motivations of managers was to take control of production away from machine operators. It is not difficult, therefore, to understand why an ideology which makes this process appear to be an inevitable part of a technical change pursued for purely economic reasons appeals to managers. If consensus can be achieved on the notion that a particular choice of technical and social organisation is most efficient, it does not necessarily follow that workers will conform to management demands, but it certainly helps. After all, generally speaking workers and their representatives do show at least some concern that their employing organisations remain competitive (5). The most alarming instance of the unquestioned acceptance of new technology was the new shop scheduling system which dramatically changed the role of progress clerks in an extremely degrading manner. Their resigned acceptance of the new methods was summed up in the comment "...that's modernisation, isn't it?" In the other cases economic justifications were generally convincing at an official level. Real working practices on the shopfloor, however, were another matter.

Of course, management intentions are not necessarily to deskill or wrest control. For instance the optical company voluntarily instigated a system of job rotation and improved working conditions. Here managers referred to increased worker satisfaction, a happier place to come to in the morning, and so on, but also, almost apologetically, they referred to the economic advantages of job rotation (shiftwork is possible, holidays are easily covered, etc.). And even the psychological advantages themselves were connected to economic benefits (less mistakes through inattention, decreased absenteeism, etc.). Management's use of the efficiency argument is thus not always sinister and consciously underhanded. Rather, it seems that there is some sense in which managers feel most secure when all their actions can be justified in terms of improved performance.

Important though they undoubtedly are, this is not the place to go into great depth on the general philosophical questions about the nature of "efficiency" and its relationship to technological change which have inevitably been raised. Rather, we have done enough to have shown how efficiency can be used as an ideological tool which legitimates social and political choices. We can now concern ourselves with the ways in which the values and interests of the actors involved help guide technical changes in particular directions, and the way these interests become embodied in the technical and social organisation of work.

To order the discussion, the assessment will be presented under the categories of the design, choice, and implementation and debugging of new technology. Each of these stages in the process of innovation will be shown to provide junctures at which actors can (and do) intervene to influence the direction of change and its organisational effects. It should, of course, be borne in mind that the distinctions between these stages are for analytical purposes only, and as the case studies made perfectly clear, are not empirically founded. On the other hand, we must also emphasise that the distinctions between the stages of innovation which are made are especially relevant to the automation of batch production rather than other types of automation. In the case of the automation of process production (chemicals, oil refineries, etc.) for instance, technical change tends to take the form of the setting up of whole new plants incorporating the latest innovations. When workers and all but top managers are introduced to the plant, decisions regarding work organisation may already be largely "built in" to the plant, and although there may be some choice over exact working practices, that choice may be extremely limited. In these cases it may be most important to concentrate on the design of the plant, since it is here where the most important social decisions have been made. In contrast, the automation of batch production is characteristically carried on machine by machine within existing plants, rather than in great leaps and in new locations, and there are thus repeated opportunities for managers to choose among alter-

natives. There is also, of course, the possibility that existing custom and practice will influence the way new equipment is used. Further, batch production tends to be carried on by smaller firms, and the majority of batches are of less than fifty components. Both these points mean automation is more difficult than in other sectors, reinforcing the tendency toward incremental innovation.

Design of Technology

The empirical material gathered in the case studies focuses mainly on the debugging and implementation stage of innovation. However, the vital importance of the design stage must be discussed. Here the recent work by David Noble in America is especially important (6). Noble traces the design of NC machine tools back to the second world war, and points out that in the initial stages of development there were two types of NC system. One, a "record-playback" system, involved the machinist making the first of a batch of components in the conventional way, using the machine's manual controls. An electronic control device would record all the movements made by the operator so that the rest of the batch would run automatically. The second type, what is now conventional NC, involves the preparation of a paper tape by programmers by encoding in "machine-readable" form the instructions for the movements of the machine tool. With this system, at least theoretically, the operator simply has to load and unload the machinery and monitor its movements - the rest is automatic. According to Noble there were no

convincing economic advantages in favour of either system over the other. Rather, the second type was developed out of social and political considerations - that is, this system meant that control over the quantity and quality of production could be taken out of the hands of the skilled machinists on the shopfloor, and placed in the hands of programmers. Programmers were assumed to be more management-oriented and thus less problematic to deal with. Any "deskilling" effects which NC systems have are thus related less to "technical necessities" than to an attempt by managers and engineers involved in their design to take control from a problematic workforce.

More recently, with the development of CNC and the proliferation of variations in the detailed design of control systems, adopting firms have more choice over the use to which they put NC (7). Of particular interest here is some current research being carried out at the Machine Tool Division of the University of Manchester Institute of Science and Technology. Howard Rosenbrock, John Boon and others have begun to examine the possibilities of designing an NC system for operator programming on the shopfloor. Already an NC lathe, which is programmed at the machine's own control computer, has been successfully demonstrated, and in fact is claimed in many respects to be economically superior to existing alternatives. The intention now is to extend the control system to a whole "flexible manufacturing system" (FMS), which involves a robot as well as two machine tools. The hope is to allow the development of a "computer-

aided craftsman" rather than reduce the operator to a semi-skilled machine minder. Most excitingly, at the same time as the more ambitious experiments with FMS's go on, commercial backers are being sought for the prototype lathe in industry, and we must now await the response.

As we shall see, with NC and other applications of electronic controls to batch production processes, adopting firms still have to choose between alternative designs, and even then important decisions have to be made on the organisation of work around the technology. However, for some computer applications relevant to batch engineering, the design of the system allows little flexibility in organisation. Our study of the computerisation of a production control system provides a good example. Here the reallocation of the tasks of the progress clerks from functional area to geographical area meant that all the skill and knowledge, and the integrity and satisfaction in work that goes with it, has been eliminated. Instead of chasing all the parts necessary for the building of a machine or group of machines, the clerk now simply arranges for the work in his section of the machine shop to be allocated in the order dictated by a computer print-out. There can be no doubt that alternative, more interesting and varied, systems could have been "computerised", and indeed the firm has now tacitly acknowledged this with recent considerations of another system with very different implications. Enid Mumford, among others, has focussed on computerised adminis-

trative systems, and in particular has looked at the way the values (or "models of man") employed by computer systems designers can influence the type of work they create for the users of new systems.

In cases such as these, where administrative and control systems are "computerised", the political mechanisms (and thus the policy implications) are very different. In particular, there is a more direct relationship between the intentions of the designer and the nature of work of the system users - in fact designers often have to work intimately with the adopting firm in order to assess their specific needs. As opposed to most instances of the design of new control devices for batch machinery - where the designer may be remote both geographically and in time - designers are present and working during "adoption", and can thus be influenced in important ways directly. It is not surprising then, that Mary Weir has been able to talk about how new computer systems can "reinforce existing hierarchies" within firms - those in positions of power can directly influence designers (8).

Choice of Technology

The official criteria for choice among alternative machinery on the market were, as we have already pointed out, highly technical. Reference was made in great detail to costs, suitability to production needs, payback periods, productivity gains, and so on. However, it became clear during the studies that choices among alternative options

were frequently coloured by considerations of the type of work they implied and, relatedly, the control issues involved.

For instance, in the case of the machine tool manufacturer, production engineers, superintendents and higher managers were divided on whether to move in the direction of operator-programmable CNC machine tools (manual data input), or to remain with conventional CNC machine tools. The choice, it was clear, was essentially a social one between shopfloor control over production (MDI machine tools) or office control (conventional CNC), and it is worth repeating the quote from the production engineer who summed up the options: "The firm has to go one of two ways. We can either retain skill on the shopfloor and have manual data input, or transfer skill into here with more tape control machines".

The different positions taken up by the various actors was clearly a reflection both of the politics of the workplace, and of the values of the individuals involved. In particular, there was a division between superintendents and foremen on the shopfloor who were in favour of MDI, and some engineers and top managers who had a strong preference for anything which would take control away from the operators (9). The superintendents and foremen certainly had a motive from their objective interests in that shopfloor control also meant the retention of managerial control in their hands. However, their stand on the issue was also a reflection of the moral value they placed on craft skills. Being

skilled machinists themselves, they identified strongly with the plight of the skilled worker subject to deskilling technology, and viewed any possibilities for retaining skills with sympathy. Some engineers saw conventional CNC as an opportunity to extend their influence within the firm, but with programming staff attempting to incorporate as much responsibility as possible for pre-production functions into their own domain, the engineers recognised the dangers of programmers attempting to usurp their traditional roles. Relevant higher managers in the firm, being mostly recent recruits, were still developing their views at the time the research was carried out, and in any case little direction had been offered by previous management teams. The choices to come, however, were clearly going to be influenced strongly by the new top managers, and also by the new American parent, which was already making its influence felt in other areas. Unfortunately what happens next is yet to be seen, but the important point has been made - that choice of technology is dependent on social values and political interests.

In the plating firm, with management openly adopting a deskilling strategy, the equipment was chosen with this end unambiguously in mind. In fact, the firm was even able to instruct the machine control system suppliers to install the system with this end in mind. The control panels for the plating process were located in a separate room so that only managers could tamper with them, and thus direct management control over quantity and quality of production could be

secured.

These two examples from the machine tool manufacturer and the plating company serve to show how the choice of technology is coloured by politics. Finally, however, we should mention the optical company where the choice of equipment, which tended to be deskilling in its consequences, appeared not to have an overt social or political dimension. The firm simply acquired "the latest". It is impossible to say how much more discretion managers could have exercised in their choices, but even assuming that it was very limited one can still point to the design of the technology (which may be out of the hands of the managers of this firm but is nonetheless subject to change by someone) and to the establishment of a work organisation around the technology (and here managers did impose their values) as junctures at which innovations could be influenced.

Implementation and Debugging

When new electronic control devices are applied to manufacturing processes, important implications for the nature of work tend to be "built in" to the machinery. As Noble and Rosenbrock point out, social choices have already been made during design. Generally the automated process has been designed away from the particular plant adopting the innovation, without reference to that plant's peculiar existing organisational arrangements - the payment system in operation, established working practices, etc. Thus to some extent the technology will be external and have

"impacts". However, there is in most instances still a good deal of "organisational choice" available, and the impacts depend very much on the use made of the machinery.

The most important point about the implementation and debugging of production technology is that it is this stage, at least as far as batch production is concerned, where people on the receiving end of technological advance - i.e., workers - can most seriously attempt to impose their own interests.

Working practices in the machine tool manufacturing firm had evolved in favour of the operators over a period of a few years. Here, as we have stated above, there was some dispute as to whether control of production should be in the hands of programmers or operators. There was in fact a "battle for control" between the interested parties, carried on with each new batch of components. As has been made clear, during the research period the operators were generally winning the battle, being in a position to choose when (and when not) they wished to carry out their own editing, or occasionally even programming. The support of operators by foremen and superintendents meant that programmers would find the appropriation of the editing function extremely difficult unless there was a significant change of policy implemented by higher management - a point recognised by the programmers themselves.

In the plating and rubber moulding firms, by contrast, management expressed a clear preference for using electronic controls in order to shift control of production to the

office, where managers (in the case of the plating company) or process control staff (in the case of the rubber moulding company) could predetermine the movements of the machinery. In both cases, however, workers succeeded in imposing their own interests, and the working practices which evolved were not to management's designs. This was because during the implementation of the new processes operators were able to become involved in the establishment of work methods with the new equipment. In the plating company, for instance, during the debugging of the new control systems it was necessary to make occasional use of a manual override until the computer programmes were perfected. Operators still use the manual override, however, in order to control both their own work pace and the quality of finish on goods. Now that "debugging" is almost complete, these practices have already become to some extent institutionalised, and managers have had to revert to the old styles of supervision in order to maintain management control and standards.

In the case of the rubber moulding firm, which found similar unwanted working practices becoming institutionalised during debugging, the next set of machinery to be introduced will be "productionised" (their phrase) away from the shop-floor in a separate development area (10). Only when machinery is ready for full-scale and uninterrupted production will workers see it. The time-study man can then time the job with work methods pre-arranged by development staffs, and the operator will have no say in the establishment of standards. In effect, only management interests will be

"built in" to the work organisation. Thus the new development area represents an attempt by management to incorporate their perceived interests into the technical organisation of the factory at the expense of the workers' interests. Designed on the basis that working practices will now be a matter for management choice only, the new development area, in a very important sense, has its own politics (11).

The evolution of working practices, then, provide a direct feedback to design considerations and, of course, to the "choice of technology" stage, strongly influencing future decisions.

The various stages of innovation described above provide junctures at which people can (and do) intervene to influence the process of technical change and its effects. In fact they provide opportunities for social policy making, albeit normally unacknowledged, which have profound influences on the nature of work. On the basis of our findings, we will now turn our attention to some of the policy issues which are raised, and how they might be better dealt with in the future.

CHAPTER FOURTEEN
SOME POLICY ISSUES

Skills and Training

One of the most important aspects of new technology is the fate of skills under its influence. Claims that computerisation deskills regardless of the social context have been made, and so have claims that the new technology inevitably deskills so long as the context of its introduction is capitalism (see chapter 3). The contribution of the case studies to the skills debate is (i) that technology is not autonomous and therefore does not have impacts regardless of the social context, and (ii) that forces of competition do not impel firms to impose specific skill structures. Rather, it was shown that the technical and social organisation of work - and thus real skills - is a negotiable phenomena, determined by social and political processes whose outcomes were never certain.

In the case of electronic and computer control of batch production, the major issue is the "transfer" of skill from work on the machine itself to work with programmes or process controls, and it is frequently commented that conceptual skills replace traditional manual skills. The notion that this necessarily entails the deskilling of the operator, and the creation of a new elite of programmers or process controllers, however, was repeatedly shown in the case studies to be an unfounded assumption. Certainly some firms - especially the plating company and the rubber

moulding company - set out with this intention. But even here workers succeeded to some extent in retaining skills on the shopfloor. In the machine tool manufacturer, some operators even went so far as to carry out their own programming, using the tape editing facility, at the machine itself. Management policies and worker responses, therefore, were shown to be centrally important in determining the skill structures of individual firms, and at this "micro" level general explanations in terms of the physical characteristics of technology and/or the wider social and economic context were of little value in themselves.

All this is not to undermine the value of analyses which make reference to the rates of diffusion of innovations, general labour market trends, and so on, but it is to question their use in explanations of events within individual firms. In particular, as far as national training programmes are concerned, it is difficult to see how aggregate level analyses can be avoided, and certainly they are likely to expose the existence of particular trends - e.g., in skill shortages or gluts - which might not otherwise be identified. But the identification of skills problems and possible training policies for individual firms must take into account the political processes involved, and even at a national level a clear understanding of the processes behind the figures is helpful. Indeed, there may be some interaction between national training programmes and job design within individual firms, since management may take skills availability into account when designing their

jobs, and workers' existing skills will influence the degree of control they wish to exercise. National training bodies thus need not be merely adaptive (1).

Our central concern, however, was with the way skill structures were generated on the shopfloor - i.e., within firms. Here, Enid Mumford, among others, has pointed out that skilled machinists could be trained in programming, so that the whole machining process remains in their hands (2), and the same must hold true for other batch production processes which were the subject of our case studies. The possibilities with the new technology are summed up in Howard Rosenbrock's image of the "computer-aided craftsman" (3). Instead of designing and using new control systems to deskill workers, they can be designed specifically as "tools" to aid craftsmen just as computers may be used by doctors to aid their diagnoses. Indeed, we found in our case study firms examples of individual operators in effect training themselves in programming and process control, and the formal institutionalisation of these working practices would be a simple matter. Deskillling strategies were, however, more dominant than others, and it would take something of a shift in political stance among managers to change this situation (4). In the meantime operators will continue to seek to exercise their skills and maintain control, albeit mainly in unorganised and subterranean ways.

(Research into new technology and skills is now continuing in the Technology Policy Unit in collaboration

with the Manpower Services Commission.)

Bargaining Issues for Trade Unions?

The most interesting issues brought to light by the case studies - those of skills and control - were never bargained over in the traditional sense. Rather, the tendency was for working practices to become established during the implementation and debugging of the technology, and then to be renegotiated, on a regular basis, sometimes with each new batch of components to be made. Working arrangements would over a period of time become incorporated into the custom and practice of the factory floor. The assumptions and interests of the various parties to the changes, and their particular positions of power within the organisations, were shown to determine outcomes, but rarely was this process of bargaining and accommodation made explicit. The coordination of workers' strategies for control was particularly weak, and worker initiatives remained largely at a subterranean or individualistic level. In the case of the machine tool manufacturer shop stewards had occasionally defended individual operators against the encroachments of programmers, but this was only at the specific request of operators on certain occasions, and the steward organisation had no conscious strategy, let alone official policy, on the issues. Our case studies repeatedly made it clear that the strength of subterranean challenges to management designs should never be underestimated, but nonetheless one might expect trade unions to take a more serious interest. Management

too might benefit by coming to terms more openly with the issues, and in fact a good deal of managerial literature already exists, as discussed in chapter 2. Consequently, we will concentrate on the problems facing workers and their representatives.

At the national level, trade unions have recognised the need to form policies to deal with the effects of technical change, and there has recently been a flurry of publications on "the new technology" calling for trade union involvement through collective bargaining and other means (5). However, so far official negotiations involving trade unions have tended to focus on issues of payment, redundancy, safety, and so on, and if unions are going to come to terms with the issues of control and skills, a major redirection of trade union concerns will be necessary. Current research by Robin Williams and Russell Moseley of the Technology Policy Unit, University of Aston, is focussing on the trade union response to new technology, and their findings should throw some light on the possibilities for a more direct union involvement (6). There is of course a great difficulty in diffusing new stances on technology to where it counts - in the stewards organisations within individual firms. But this is the only place where effective bargaining on the issues can take place. The rapidly rising importance of the shop stewards movement in recent years (7) should be taken advantage of, and the task now at hand is to secure effective steward involvement.

Over ten years ago Hugh Scanlon summarised the major

problems of dealing with technical change:-

"So what is involved here? The main and most immediate objective which is the starting point for industrial democracy is to oppose the position where organised labour can only react to management decisions and fight a difficult rear-guard action to reduce the magnitude of their impact. It must be recognised that conventional collective bargaining systems are not appropriate for dealing with technological changes, particularly when....planning has been reduced from decades to months. It is no longer possible or desirable to wait for the end of a specific contract period to negotiate, when management's decisions are already and quite arbitrarily in the pipeline. These decisions may threaten technological unemployment, obsolescence of skills, disappearance of trades and industries and geographical displacement of the workers themselves. To protect workers adequately, we must be involved with decisions as they occur. We need an anticipatory function at the planning and implementation stages. This is getting to the kernel of our struggle for industrial democracy." (8)

Thus the traditional methods of bargaining are wholly inadequate for technical change. Indeed, in the one instance in the case studies where a formal agreement on new technology and working practices was reached by union and management (in the rubber moulding company), it was drawn up after the change was implemented, and was concerned solely with matters of pay and effort (9). The need is for workers' organisations to become involved at the earliest possible stage, and this will involve challenging management's prerogative with regard to decision making on technology. One instance will suffice: the machinists who currently carry out their own editing of tapes (and occasionally programming) could

reinforce their positions if unions could persuade management to move in the direction of manual data input machines in favour of conventional, office-programmed machines. By failing to influence these decisions on choice of technology the machinists remain in a precarious position, and a radical change in management's policy on working arrangements could easily mean that the working practices now established could be transformed. Unfortunately shop stewards in the plant simply do not see this area of decision making as their legitimate concern, and indeed only one steward was even aware of the difference between MDI and conventional CNC. As is generally the case, the major concern of the union was that any labour displaced by CNC would be reabsorbed elsewhere, and once assurances were gained on this issue, the stewards felt they had had their say. Assuring that labour displacement is minimised is no doubt a vital task for trade unionists. However, as Robert Blauner pointed out, for the past forty years:

"....the unions have been mostly concerned with the problem of maintaining the jobs of their members, and therefore they have been relatively unconcerned about the kind of work their people do. With the realistic fears of unemployment brought about by further technological change, it seems likely that this 'blind spot' in union outlook might continue for another forty years." (10)

Probably the single most useful, and easiest to implement, measure which trade unions could take in order to eliminate their "blind spot" is to make frequent use of good research into the specific implications of all new

technology introduced into plants. This thesis hopefully points to the areas which such research should seek to illuminate. The steward organisation is frequently well established. The problem is one of developing awareness of the issue at the earliest possible stage.

NOTES AND REFERENCES

NOTES AND REFERENCES TO CHAPTER ONE

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2. For an outline of the definitions of technology employed by the various authors below see J.C.Taylor, Technology and Planned Organisational Change (Michigan: Ann Arbor, 1971), chapter 1.
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4. J.W.Kuhn, Bargaining in Grievance Settlement (New York: Columbia University Press, 1961).
5. Ibid., p.148. A thorough summary and criticism of this and similar theses is found in R.Hyman, "Explanations of Strike-proneness" in B.Barrett et al. (eds.), Industrial Relations and the Wider Society (London: Collier MacMillan, 1975), pp.334-347.
6. M.Marchington, "Shopfloor Control and Industrial Relations" in J.Purcell and R.Smith (eds.), The Control of Work (London: MacMillan, 1979), pp.133-155.
7. D.Gallie, In Search of the New Working Class (Cambridge: Cambridge University Press, 1978), part 1.
8. J.Woodward, Industrial Organisation: Theory and Practice (Oxford: Oxford University Press, 1965), p.50.
9. C.R.Walker and R.H.Guest, Man on the Assembly Line (Cambridge, Mass.: Harvard University Press, 1956).
10. M.Seeman, "On the Meaning of Alienation", American Sociological Review, XXIV, 1959, pp.783-791.

11. R.Blauner, Alienation and Freedom (Chicago: University of Chicago Press, 1964).
12. See G.K.Ingham, Size of Industrial Organisation and Worker Behaviour (Cambridge: Cambridge University Press, 1970) for an outline of this school. For a commentary on the debate between the "technology" school and the "size" school with regard to organisational structure, see J.Child and R.Mansfield, "Technology, Size and Organisational Structure", Sociology, vol.6, no.3, September 1972, pp.369-393. Child and Mansfield suggest that size probably does have greater associations with structure overall, but that the structural variables centred on the workflow are more directly associated with technology. Further, the larger the organisation, the less chance the dominant production technology has of affecting the more remote administrative and hierarchical structure.
13. R.Blauner, op. cit., p.8
14. Ibid., p.182.
15. Blauner's analysis of the automobile worker owes a great deal to Walker and Guest's classic (above).
16. R.Tenne and B.Mannheim, "The Effect of the Level of Production Technology on Worker's Orientations and Responses to the Work Situation" in M.R.Haug and J.Dofny, Work and Technology (London: Sage, 1977), pp.61-80.
17. J.C.Taylor, op. cit.
18. Marx's original concept of alienation is outlined in K.Marx, Economic and Philosophic Manuscripts of 1844 (Moscow: Progress Publishers, 1977). Here Marx distinguishes between what we might call market alienation -

alienation from the product of the labour process; and technological alienation - alienation from the labour process itself. Blauner concentrates solely on the latter, on the grounds that: "Unlike the absence of control over the immediate work process, 'ownership powerlessness' is a constant in modern industry, and employees, therefore, normally do not develop expectations for influence in this area" (R.Blauner, op. cit., p.17). Thus Blauner has been accused of restricting his attention to processes which occur within a framework of alienation. Further, by restricting his attention to subjective feeling states, Blauner ignores the problem of what Marx called "false-consciousness". As he admits himself: "...despite the lack of any conscious desire for control in this area, we cannot know for certain whether or not the worker's alienation from ownership unconsciously colours the whole quality of his experience in the factory...." (ibid., p.17). Blauner chooses to ignore this problem and goes ahead with an analysis based largely on attitude surveys - the empirical results having more in common with job satisfaction surveys than anything else.

Blauner has also been criticised on other grounds. In particular his data base has been shown to be highly suspect considering his extravagant claims (perhaps indicating the extent to which Blauner opportunistically expressed a trend in current thought rather than carry out an exceptional piece of research). A full criticism of his thesis can be found in J.E.T.Eldridge, Sociology and Industrial Life (London: Michael Joseph, 1971), pp.183-195.

19. Various authors have summarised the "technological implications" school. See for instance D.Silverman, The Theory of Organisations (London: Heinemann, 1970), pp.100-109. Also see M.Rose, op. cit., pp.173-223.

20. See for instance F.C.Mann and L.R.Hoffman, Automation and the Worker (New York: Holt Dryden, 1960), and J.D.Thompson, Organisations in Action (New York: McGraw Hill, 1967).
21. R.Blauner, op. cit., p.182.
22. The most famous author of this school is J.R.Bright. See his Automation and Management (Boston: Harvard Business School, 1958). For a summary of these pessimistic determinists, see J.C.Taylor, op. cit. That there is no clear cut and uniform impact of automation is in fact admitted by Blauner, though unfortunately only in a footnote. Referring to his U-curve, he comments: "This does not imply that future developments in automation will result simply in a continuation of the major trend toward less alienation. Automation will take many forms besides continuous-process production..." (R.Blauner, op. cit., p.182n).
23. Ibid., p.31
24. D.Silverman, op. cit., p.108-109. Silverman's emphasis.
25. F.Bechhofer, "The Relationship Between Technology and Shopfloor Behaviour: a Less Heated Look at the Controversy" in D.O.Edge and J.N.Wolfe (eds.), Meaning and Control: Essays in Social Aspects of Science and Technology (London: Tavistock, 1973), pp.121-142.
26. H.Beynon and R.M.Blackburn, Perceptions at Work: Variations Within a Factory (Cambridge: Cambridge University Press, 1972), p.156.
27. J.H.Goldthorpe et al., The Affluent Worker: Industrial Attitudes and Behaviour (Cambridge: Cambridge University Press, 1968).

28. A.N.Turner and P.R.Lawrence, Industrial Jobs and the Worker (Harvard: Harvard University Press, 1966).
29. For a fuller discussion see, for instance, H.Beynon and R.M.Blackburn, op. cit.
30. G.Salaman, Class and the Corporation (London: Fontana, 1981), p.105-106.
31. E.Thorsrud, "Job Design in the Wider Context" in L.E.Davis and J.C.Taylor (eds.), Design of Jobs (Harmondsworth: Penguin, 1972), pp.451-459.
32. D.Wedderburn and R.Crompton, Workers Attitudes and Technology (Cambridge: Cambridge University Press, 1972).
33. See J.Westergaard, "The Rediscovery of the Cash Nexus" in R.Milliband and J.Saville (eds.), The Socialist Register (London: Merlin Press, 1970), pp.111-138.
34. M.Burawoy, Manufacturing Consent: Changes in the Labour Process Under Monopoly Capitalism (Chicago: University of Chicago Press, 1979), p.138. Burawoy goes on to discuss some examples of the ways workers adapt to alienating work organisations. But the best and most readable case is D.Roy, "Banana Time: Job Satisfaction and Informal Interaction" in G.Salaman and K.Thompson (eds.), People and Organisations (London: Longman, 1973), pp.205-222.
35. A.Gorz, "Work and Consumption" in P.Anderson and R.Blackburn (eds.), Towards Socialism (London: Fontana, 1965), p.319. Gorz's emphasis.
36. M.Burawoy, op. cit., p.156-157.

37. Despite these recent theoretical developments, work in the "technological implications" tradition continues today. See for instance J.Forslin, A.Sarapata and A.M.Whitehill (eds.), Automation and Industrial Workers: a Fifteen Nation Study, vol.1, part 1 (Oxford: Pergamon Press, 1979).

NOTES AND REFERENCES TO CHAPTER TWO

1. M.Rose, Industrial Behaviour: Theoretical Development Since Taylor (Harmondsworth: Penguin, 1978), pp.187-194.
2. Detailed expositions of scientific management and Taylorism can be found in ibid., pp.29-62, and in G.Friedman, The Anatomy of Work (London: Heinemann, 1961).
3. See F.W.Taylor, The Principles of Scientific Management (New York: Harper and Row, 1947).
4. A.L.Friedman, Industry and Labour (London: MacMillan, 1977), p.93.
5. Quoted P.Warr and T.Wall, Work and Well-being (Harmondsworth: Penguin, 1975), p.20.
6. A detailed analysis of the "human relations" school can be found in M.Rose, op. cit., pp.101-172.
7. See ibid., pp.106-112.
8. That is, working too fast or too slow was often sanctioned by the group in order to gain some control over piecework earnings and to prevent "ratebusting". The practice has commonly been remarked upon by industrial sociologists (among others), and often goes under the suggestive titles of "restriction of output" or "systematic soldiering".
9. See A.H.Maslow, Motivation and Personality (New York: Harper and Row, 1954).
10. D.McGreggor, The Human Side of the Enterprise (New York:

McGraw-Hill, 1960).

11. F.Herzberg, B.Mausner and B.Snyderman, The Motivation to Work (New York: Wiley, 1959). See also F.Herzberg, Work and the Nature of Man (London: Staples Press, 1968).
12. One has to wonder whether salary was a "motivator" or a "hygiene" factor for Herzberg himself. He charged £300 per day per head for seminars where he lectured that money was not a motivator! See D.Hull, The Shop Steward's Guide to Work Organisation (Nottingham: Spokesman Books, 1978), p.109.
13. Since then, a host of industrial psychologists and sociologists have contributed to a burgeoning body of literature on job satisfaction. For an overview see M.Weir, Job Satisfaction (London: Fontana, 1976).
14. This practice, commented on by various students of industry, involves one worker frantically performing both his own job and the job of the man standing next to him. Alternating every hour, they can cut their working time in half. See R.Blauner, Alienation and Freedom (Chicago: University of Chicago Press, 1964). My own research uncovered at least two instances of worker-initiated job enlargement. In one a group of machine operators used their extra skills and knowledge in order to negotiate better times from the work study men, whose knowledge of methods was now no better than that of the operators. In another, a group of operators justified their wish to become involved in programming in terms of "maintaining self respect" and "increasing satisfaction". (These two instances are presented in chapter 10 and chapter 11 respectively.)
15. R.G.Miller et al., "Job Rotation Raises Productivity",

Industrial Engineer, vol.5, no.6, 1973, pp.24-26.

16. P.A.Hallam, "An Experiment in Group Working" in M.Weir (ed.), op. cit., pp.193-201.
17. J.F.Biggame and P.A.Stewart, "Job Enlargement: a Case study" in L.E.Davis and J.C.Taylor, Design of Jobs (Harmondsworth: Penguin, 1972), pp.264-276.
18. C.R.Walker and R.H.Guest, Man on the Assembly Line (Cambridge, Mass.: Harvard University Press, 1952).
19. D.Birchall, Job Design (Epping: Gower Press, 1975).
20. F.Herzberg, "One More Time: How do you Motivate Employees?" in M.M.Gruneberg (ed.), Job Satisfaction (London: MacMillan, 1976), p.26.
21. W.W.Daniels and N.McIntosh, "Job Enrichment in Context" in M.Weir (ed.), op. cit., p.249. The disruption of informal social groups was in fact the main reason for the small amount of resistance to management's attempt to rotate workers in our optical company case study (see chapter 9).
22. W.J.Paul and K.Robertson, Job Enrichment and Employee Motivation (Epping: Gower Press, 1970).
23. P.A.Hallam, op. cit.
24. D.Birchall, op. cit., summarises the claims these researchers make with regard to both social and economic benefits.
25. S.Srivastva et al., Job Satisfaction and Productivity (Cleveland: Case Western University Press, 1975), p.137.

26. F.H.M.Blackler and C.A.Brown, Job Redesign and Management Control: Studies in British Leyland and Volvo (Farnborough: Saxon House, 1978), p.39.
27. W.W.Daniels and N.McIntosh, op. cit., p.245.
28. S.Cotgrove, J.Dunham and C.Vamplew, The Nylon Spinners (London: George Allen and Unwin, 1971), p.102.
29. See Daniel Bell, The Coming of Post-industrial Society (New York: Basic Books, 1973).
30. F.Tönnies, Community and Association (London: Routledge and Keegan Paul, 1955).
31. One commentator has gone so far as to suggest that this concern represents the basis of sociology itself. That is, the entire history of sociological analysis could be rewritten as "...the story of successive attempts to solve the fundamental dilemma of how to get from instrumental action and society to moral action and community." - A.Dawe, "Theories of Social Action" in T.Bottomore and R.Nisbet (eds.), A History of Sociological Analysis (London: Heinemann, 1978), p.390.
32. D.Bell, op. cit., p.127 and 129.
33. J.I.Gershuny, After Industrial Society? (London: MacMillan, 1979), p.139. My emphasis.
34. New job design programmes are placed in this context by K.Kumar, Prophecy and Progress: the Sociology of Industrial and Post-Industrial Society (London: Allen Lane, 1978).
35. Introduction in M.Weir (ed.), op. cit., p.19.

36. See A.Cherns, "Work or Life" in R.Felix Geyer and David R.Schweitzer, Theories of Alienation (Leiden: Martinus Nijhoff, 1976), pp.227-244.
37. L.E.Davis and J.C.Taylor, "Technology, Organisation and Job Structure" in R.Dubin (ed.), Handbook of Work, Organisation and Society (Chicago: Rand-McNally, 1976).
38. Quoted D.Mankin, Toward a Post-Industrial Psychology (New York: Wiley, 1978), p.93.
39. See L.E.Davis, "Job Satisfaction Research: the Post-Industrial View" in L.E.Davis and J.C.Taylor (eds.), op. cit., pp.154-176.
40. A.Cherns, op. cit., p.234. My emphasis.
41. For a detailed summary of the "principles for good socio-technical design" see A.Cherns, "The principles of Socio-technical Design", Human Relations, vol.29, no.8, 1976, pp.783-792.
42. L.E.Davis et al., "Current Job Design Criteria", Journal of Industrial Engineering, vol.6, 1955, pp.5-11.
43. This is the case, for instance, with Trist and Bamforth's study of work reorganisation at the coalface. See E.Trist and K.Bamforth, "Technicism: Some Effects of Material Technology" in T.Burns (ed.), Industrial Man (Harmondsworth: Penguin, 1969), pp.331-358.
44. Countless social scientists have made the pilgrimage to Kalmar, which a few years ago was as good an excuse to travel abroad as Mondragon is today. Thus many reports on the new factory exist. Perhaps the two best discussions are one by a Volvo director, and one by two radicals. They are, respectively, P.Gyllenhammar,

People at Work (Reading: Addison Wesley, 1977) and F.H.M.Blackler and C.A.Brown, op. cit. A recent study which takes a more general look at changes in work organisation in Sweden is S.Aguren and J.Edgren, New Factories: Job Design Through Factory Planning in Sweden (Stockholm: Swedish Employers Confederation, 1980), and a blow-by-blow account of developments throughout the European motor industry is found in: Commission of the European Communities (Employment and Social Affairs), Report on the Working Conditions in the European Automobile Industry (Part 1, 1977).

An interesting question is whether Volvo's use of autonomous work groups is simply one of alternative possible solutions to the problems of dissatisfaction and disaffection caused by assembly line working, since some are now making humanistic claims for the use of robotics on the most dangerous and/or tedious assembly tasks (e.g., spot welding). This impression is given in G.Jessup, Technology as if People Mattered (Department of Employment, Work Research Unit: Occasional Paper no.12, 1978).

45. M.Weir, "Are Computer Systems and Humanised Work Compatible?" in R.N.Ottaway (ed.), Humanising the Workplace (London: Croom Helm, 1977), pp.44-64.
46. See Lisl Klein, "The Production Engineer's Role in Industrial Relations", Production Engineer, vol.57, no.12, December 1978, pp.27-29. For a detailed description of such an experiment see T.Lupton, "Efficiency and the Quality of Work Life - the Technology of Reconciliation", Organisational Dynamics, vol.4, no.2, Autumn 1975, pp.68-50.
47. For details see D.Jenkins, The West German Humanisation of Work Programme: a Preliminary Assessment (Department of Employment, Work Research Unit, Occasional Paper no.8,

July 1978).

48. T.Lupton, I.Tanner and T.Schnelle, "Manufacturing System Design in Europe" in G.L.Cooper and E.Mumford (eds.), The Quality of Working Life in Western Europe (London: Associated Business Press, 1979), p.50.
49. For a summary of some of these experiments see F.E.Emery and E.Thorsrud, Democracy at Work: the Report of the Norwegian Industrial Democracy Programme (Leiden: Martinus Nijhoff, 1976).
50. See for instance S.Aguren and J.Edgren, op. cit.
51. French experiments are summarised in G.Trepo, "Improvement of Working Conditions and Job Redesign in France" in G.L.Cooper and E.Mumford (eds.), op. cit., pp.159-179.
52. In that experiments have been conducted in process and textile industries rather than in traditional manufacturing industry, Britain presents a major divergence. See T.Lupton, I.Tanner and T.Schnelle, op. cit., p.52. These firms often employ their own specialists in work organisation - partly a reflection of, no doubt, the organisational slack afforded to capital-intensive firms in very strong economic positions.
53. My own experience of the work of the WRU suggests that even gaining access to firms is often found to be a major problem.
54. Keith E.Dickson, The Impact of Industrial Automation: a Case Study (University of Aston in Birmingham, Technology Policy Unit: Unpublished MSc dissertation, 1978).
55. T.Nichols and H.Beynon, Living With Capitalism (London: Routledge and Keegan Paul, 1977).

56. "Chemco" worker: quoted T.Nichols, "The Socialism of Management: Some Comments on the New Human Relations", Sociological Review, vol.23, no.2, 1975, p.253.
57. F.H.M.Blackler and C.A.Brown, Whatever Happened to Shell's New Philosophy of Management? (Farnborough: Saxon House, 1980).
58. M.Bosquet, "The Prison Factory", New Left Review, no.73, May-June 1972, pp.23-34.
59. T.Nichols, op. cit.
60. Quoted J.E.T.Eldridge, Sociology and Industrial Life (London: Michael Joseph, 1971), p.195.
61. T.Lupton, I.Tanner and T.Schnelle, op. cit., p.53.
My emphasis.
62. See for instance L.Baritz, The Servants of Power (Weslayan, Connecticut: University Press, 1960).
63. This is also true on a wider level. For instance, in West Germany it is the political groups to the left of centre who tend to be most enthusiastic about new forms of work organisation. The extreme left and extreme right (for different reasons of course) both tend to be very much against the experiments.
64. M.Bosquet, op. cit.
65. J.F.Bolweg, Job Design and Industrial Democracy (Leiden: Martinus Nijhoff, 1976), pp.64-65.
66. D.Hull, op. cit.

NOTES AND REFERENCES TO CHAPTER THREE

1. H.Braverman, Labour and Monopoly Capital: the Degradation of Work in the Twentieth Century (New York: Monthly Review Press, 1974).
2. Ibid., p.38. Braverman's emphasis.
3. Classic texts from this school of thought include E.Mansfield, The Economics of Technological Change (New York: Norton, 1968); N.Rosenberg (ed.), The Economics of Technological Change (Harmondsworth: Penguin, 1971); and K.Norris and J.Vaisey, The Economics of Research and Technology (London: Allen and Unwin, 1973).
4. E.Mansfield, op. cit., p.99.
5. See for instance C.Freeman, The Economics of Industrial Innovation (Harmondsworth: Penguin, 1974), pp.161-197, and: Cabinet Office, Advisory Council for Applied Research and Development (ACARD), Industrial Innovation (London: HMSO, December 1978). It should be emphasised here that scientific and technical endeavour is generally assumed to be neutral. Research priorities may be affected by institutional interests, and the order in which advances occur. But the quality of output is held to be independent of any political interests.
6. For example see L.Nabseth and G.F.Ray, The Diffusion of New Industrial Processes (Cambridge: Cambridge University Press, 1974).
7. See E.Mansfield, op. cit., chapter 5.
8. A.Touraine, Workers Attitudes to Technical Change (Paris: OECD, 1965).

9. OECD International Seminars 1966-5, Adjustment of Workers to Technical Change at Plant Level (Paris: OECD, 1967). See especially pp.23-40 and pp.95-111.
10. See for instance R.M.Bell, Changing Technology and Manpower Requirements in the Engineering Industry (Sussex: Sussex University Press, 1972).
11. P.Senker et al., Technological Change, Structural Change and Manpower in the UK Toolmaking Industry (Watford: Engineering Industry Training Board, 1976), p.51.
12. See for instance N.Swords-Isherwood and P.Senker (eds.), Microelectronics and the Engineering Industry: the Need for Skills (London: Frances Pinter, 1980), chapter 9.
13. Emma Bird, Information Technology in the Office: the Impact on Women's Jobs (Manchester: Equal Opportunities Commission, September 1980).
14. Of course, the various authors within the innovation school are restricted by this limitation to greater or lesser degrees, and a thorough analysis would show their various positions. A recent work which does manage to introduce a good deal of social and political context to "innovations" is G.Rosegger, The Economics of Production and Innovation (Oxford: Pergamon Press, 1980).
15. P.A.Baran and P.M.Sweezy, Monopoly Capital (Harmondsworth: Penguin, 1968).
16. H.Braverman, op. cit., p.57-8.
17. Ibid., p.171.

18. K.Marx, Capital, vol.1 (London: Lawrence and Wishart, 1974), p.351. Marx provides a lengthy discussion of technology in chapter XV, "Machinery and Modern Industry".
19. Braverman's discussion of machine tools is found op. cit., pp.195-203.
20. Ibid., p.202.
21. See H.Shaiken, "Numerical Control of Work: Workers and Automation in the Computer Age", Radical America, vol.13, no.6, November-December 1979.
22. See M.J.E.Cooley, "Taylor in the Office" in R.N.Ottaway (ed.), Humanising the Workplace (London: Croom Helm, 1977), pp.65-77. Also see his "Contradictions of Science and Technology in the Production Process" in H.Rose and S.Rose (eds.), The Political Economy of Science (London: MacMillan, 1976), pp.72-95.
23. See Conference of Socialist Economists: Microelectronics Group, Microelectronics: Capitalist Technology and the Working Class (London: CSE Books, 1980).
24. S.Marglin, "The Origins and Functions of Hierarchy in Capitalist Production" in T.Nichols (ed.), Capital and Labour: Studies in the Capitalist Labour Process (London: Fontana, 1980), pp.237-254.
25. However, analysing in a precise and systematic fashion the effects of these changes is another matter. An outline of the dynamics of "industrial deskilling" and "cyclical deskilling" is found in D.J.Lee, "Skill, craft and Class: a Theoretical Case", Sociology, vol.15, no.1, pp.56-78.

26. H.Braverman, op. cit., p.200.
27. D.F.Noble, "Social Choice in Machine Design: the Case of Automatically Controlled Machine Tools" in A.Zimbalist (ed.), Case Studies in the Labour Process (New York: Monthly Review Press, 1979), pp.18-50.
28. The term "frontier of control" comes from Carter L.Goodrich's The Frontier of Control (London: Pluto Press, 1975), which was published more than 50 years ago.
29. For these and other examples see A.Elger, "Valorisation and Deskillling: a Critique of Braverman", Capital and Class, vol.7, Spring 1979. For a recent Marxist discussion which, as the title of the book implies, recognises the active presence of the working class in a lengthy analysis of the labour process, see R.C.Edwards, Contested Terrain: the Transformation of the Workplace in the Twentieth Century (London: Heinemann, 1979).
30. A.Elger, op. cit. Also see R.Coombs, "Labour and Monopoly Capital", New Left Review, no.107, 1978, pp.79-96. A recent empirical discussion of NC applications by Bryn Jones shows clearly that the deskilling strategy is not universal, and that divisions of labour around the new technology depend upon firms' product markets, pre-existing structures of management control, and upon the traditions, strengths and strategies of the trade unions concerned. See Bryn Jones, Destruction or Redistribution of Engineering Skills? The Case of Numerical Control (University of Bath: Conference Paper, 1979). A more complete version of the arguments is forthcoming.
31. Thus Palmer has commented: "Braverman is limited in his understanding of the extent to which working class opposition 'defeated' Taylorism and pushed capital to employ

more subtle means of control in its quest for authority": quoted from B.Palmer, "Class, Conception and Conflict: the Thrust for Efficiency, Managerial Views of Labour, and the Working Class Rebellion, 1903-1922", Review of Radical Political Economy, vol.7, no.2, 1975, p.7.

32. See for instance A.L.Friedman, Industry and Labour: Class Struggle at Work and Monopoly Capitalism (London: MacMillan, 1977), where management strategies are held to vary between a "direct control" and a "responsible autonomy" form.
33. Some managerial theorists would today even go so far as to argue that the use of these programmes can explain the vast difference in competitive position between, for instance, the UK and Japan's manufacturing industries - i.e., Japan uses them, Britain does not. In other words, the effective translation of labour power into labour is now best secured through the responsible autonomy strategy. See for instance a recent newspaper article by Frank Price, "Look West Young Man - as Japan Once Did", The Guardian, Thursday 10 September 1981, p.25.
34. One such is T.Cutler. See his "The Romance of Labour", Economy and Society, vol.7, no.1, 1978. Theo Nichols defends the romantic view in the introduction to his reader on "the labour process", commenting that "...deep down, there lurks an 'anthropology of humanism'": quoted from T.Nichols (ed.), op. cit., p.18.
35. Marx's view of human nature as embodied in a "species essence" is expounded in K.Marx, Economic and Philosophic Manuscripts of 1844 (Moscow: Progress Publishers, 1977).

36. See A.Maslow, "A Theory of Human Motivation", Psychological Review, vol.50, 1943, pp.370-396.
37. Mumford argues along these lines, for instance, in E.Mumford, "The Design of Work: New Approaches and New Needs" in J.E.Rijnsdorp (ed.), Case Studies in Automation Related to Humanisation of Work (Oxford: Pergamon Press, 1979), pp.9-17.

NOTES AND REFERENCES TO CHAPTER FOUR

1. A.L.Friedman, Industry and Labour: Class Struggle at Work and Monopoly Capitalism (London: MacMillan, 1977).
2. Others have used the centre-periphery dichotomy to explain differences in labour markets across whole nations. Thus, for instance, the use of immigrant labour is explained in these terms. See for example S.Castles and G.Kosack, "The Function of Labour Immigration in Western European Capitalism" in T.Nichols (ed.), Capital and Labour: Case Studies in the Capitalist Labour Process (London: Fontana, 1980), pp.117-137.
3. One of the main reasons why many Marxists, including Friedman, prefer not to see quality of work life issues as morally or politically inspired by managers has been outlined in chapter 2. That is, the problem of false consciousness is raised - new forms of work organisation can only subvert the development of a "revolutionary" workers' consciousness. Reform only delays the revolution.
4. A.L.Friedman, op. cit., p.84-5. My emphasis.
5. J.F.Bolweg, Job Design and Industrial Democracy (Leiden: Martinus Nijhoff, 1976). D.Hull, A Shop Steward's Guide to Work Organisation (Nottingham: Spokesman Books, 1978).
6. B.Hedberg and E.Mumford, "The Design of Computer Systems: Man's Vision of Man as an Integrated Part of the System Design Process" in E.Mumford and H.Sackman (eds.), Human Choice and Computers (Oxford: North Holland, 1975), pp.31-60.

7. An example of the design of a system based on Theory X values has been presented by Mary Weir (see chapter 2).
8. An article urging social scientists to take up "cultural context" as the prime explanatory factor for variations in organisations is A.Sorge, "The Cultural Context of Organisation Structure: Administrative Rationality, Constraints and Choice" in M.Warner (ed.), Organisational Choice and Constraint (Farnborough: Saxon House, 1978), pp.57-78. A discussion of the sources of assumptions and values of engineers generally is found in L.Klein, New Forms of Work Organisation (Cambridge: Cambridge University Press, 1976), chapter 2.
9. Ibid., chapter 2.
10. Ibid., chapter 2.
11. See B.Jones, Destruction or Redistribution of Engineering Skills? The Case of Numerical Control (University of Bath: Conference Paper, 1979).
12. J.Child, "Organisation Structure, Environment and Performance: the Role of Strategic Choice", Sociology, vol.6, no.1, 1972, pp.1-22. A recent reader which explores the complex theoretical issues raised by notions of choice in organisations generally is M.Warner (ed.), op. cit.
13. J.Child, op. cit., p.16.
14. J.Pfeffer, Organisational Design (Illinois: AHM Publishing Corporation, 1978), p.109-10.
15. See for instance D.Bloor, Knowledge and Social Imagery (London: Routledge and Keegan Paul, 1976).

16. S.Melman, "Alternative Criteria for the Design of Means of Production", Theory and Society, vol.10, no.3, May 1981, p.335.

NOTES AND REFERENCES TO CHAPTER FIVE

1. A very brief introduction to the meaning and uses of "microchip technology" can be found in Department of Industry, Microelectronics: the New Technology (London: HMSO, 1978). For a more detailed discussion of the development of microelectronics, see E.Braun and S.MacDonald, Revolution in Miniature (Cambridge: Cambridge University Press, 1978).
2. See E.Braun, The Dilemma of Automated Production (Technology Policy Unit, University of Aston: Unpublished paper, 1978).
3. E.Braun, Technological Change and Unemployment (Technology Policy Unit, University of Aston: Unpublished paper, 1978).
4. C.Jenkins and B.Sherman, The Collapse of Work (London: Eyre Methuen, 1979).
5. A comprehensive discussion of the more general employment issues associated with the new technology is found in R.Rothwell and W.Zegveld, Technical Change and Employment (London: Frances Pinter, 1979).
6. For a summary of the different effects of automation in each of these sectors see J.Child, "Technical Progress" in B.Barrett et al. (eds.), Industrial Relations and the Wider Society (London: Collier MacMillan, 1975), pp.144-162.
7. Science Research Council: Working Party Report, "NC Machine Tool Systems" in Colloquium on Robotics, Paper no.8 (Glasgow: National Engineering Laboratory, 30-31 March 1978).

8. This is no longer simply because microelectronics make the machines significantly cheaper - most control systems are already only a small part of the total cost of a machine tool - but because they will facilitate the development of more powerful NC systems.
9. The technical problems associated with NC technology are discussed S.K.Bhattacharyya, Penetration and Utilisation of NC/CNC Machine Tools (Science Research Council, Engineering Board, Manufacturing Technology Committee: Working Party Report, November 1976). The major non-technical reasons for the failure of the UK engineering industry to take up NC on a significant scale are to do with the quality of British management. See N.Swords-Isherwood and P.Senker, "Automation in the Engineering Industry", Labour Research, vol.67, no.11, November 1978, pp.230-231, where a comparison of the attitudes of British and German management and engineers is made. German managers cope better, they suggest, due to their superior organisation, training and education.
10. Traditionally a 16% utilisation rate has been considered good going, and even slight improvements on that figure make good economics. Utilisation rates of around 60% are often claimed for NC systems. See P.Marsh, "Towards the Unmanned Factory", New Scientist, 31 July 1980, pp.373-377. A full discussion of NC costs and the problem of utilisation is found in S.K.Bhattacharyya, op. cit. His survey of seventy companies found only 5% of firms "fully exploiting" NC, and he recommends better organisation of support functions (maintenance, tooling, production control, etc.) in order to improve utilisation.
11. A detailed discussion of the technical advantages of CNC over NC is found in N.C.Ferguson, "A History of Numerically Controlled Machine Tools", Chartered Mecha-

nical Engineer, September 1978, pp.89-92.

12. A technical description of some of the latest CNC systems is found in P.Marsh, "A Fresh Start for British Machine Tools", New Scientist, 26 February 1981, pp.544-546. This article is especially interesting since it comments on the state of British machine tool control system design.
13. The machine tool manufacturer discussed in chapters 11 and 12 was devoting some attention to this possibility, but certainly it was not yet a serious proposition.
14. A good - if rather over-dramatic - summary of micro-electronic applications in batch production can be found in Conference of Socialist Economists, Microelectronics: Capitalist Technology and the Working Class (London: CSE Books, 1980), chapter 6. Other chapters give outlines of applications in other sectors.
15. Remmerswaal's arguments are summarised in R.Rothwell and W.Zegveld, op. cit.
16. N.Swords-Isherwood and P.Senker (eds.), Microelectronics in the Engineering Industry: the Need for Skills (London: Frances Pinter, 1980), chapter 9.
17. The blatantly negative physical and social consequences of shiftwork are well documented. See for instance I.I.Wedderburn, Are Shiftworkers Supermen? (Paper given at the Annual Meeting of the British Association for the Advancement of Science, 3-7 September 1979).
18. E.Christensen, Automation and the Workers (London: Labour Research Publications, 1968), part 1.

19. N.Swords-Isherwood and P.Senker (1978 and 1980), op. cit.
20. This type of control system has already been mentioned in chapter 3. Today it is virtually extinct.
21. N.Swords-Isherwood and P.Senker (1978), op. cit., p.231. Their emphasis.
22. Jeffrey Pfeffer, Organisational Design (Illinois, US: AHM Publishing, 1978).

NOTES AND REFERENCES TO CHAPTER SIX

1. Simply passing through this area is an experience highly recommended: the train from Birmingham New Street to Wolverhampton is the most comfortable means, but some of the very best views of the industrial landscape can be gained by travelling upstairs on a double decker bus from Birmingham bus station to the terminus at Dudley.
2. A detailed description of the region's industry is found in P.A.Wood, Industrial Britain: the West Midlands (Newton Abbott: David and Charles, 1976). For a recent discussion of the region's economic ills see P.A.Wintour, "The Creation of an Industrial Desert", New Statesman, 29 August 1980, pp.7-9.
3. A few firms which began as hopeful possibilities for case studies were, after one or two visits, closed off before further research could be conducted. Fortunately, alternative options were always available throughout this research project, and thus no serious problem was posed.
4. This does not mean that all technical decisions incorporate social and political elements - but it does mean that the ones which do not are likely to be naive - as managers and engineers are likely to find out later when the social consequences of their decisions are revealed.
5. C.Bell, "Studying the Locally Powerful: Personal Reflections on a Research Career" in C.Bell and S.Encel (eds.), Inside the Whale: Ten Personal Accounts of Social Research (Oxford: Pergamon Press, 1978), pp.14-40.
6. In my own case, many problems of access were overcome because of the involvement of two such people in the

early stages of the research. See below.

7. E.Braun, R.Moseley and B.Wilkinson, "Manufacturing Innovation in the West Midlands Materials Forming Industry", Omega, forthcoming in 1981.
8. Strictly speaking, the spectacle manufacturing firm was engaged in unit production. However, unit and small batch production, for our purposes, can be categorised together.

NOTES AND REFERENCES TO CHAPTER SEVEN

1. The status of these twenty seven cases as "pilot studies" has been discussed in chapter 6.
2. For a broad discussion of NC machining technology see chapter 5.
3. It is now possible to discern a trend towards operator-programmable CNC machines. Incorporating a microprocessor in the machine's own control cabinet, they are programmable at the machine itself, during the production of the first of a batch. This type of system, it seems, is often particularly attractive to the smaller engineering concern because it eliminates the need for expensive back-up facilities - especially a separate programming department. One such machine was used by the machine tool manufacturer which takes up chapter 11, and will be discussed in more depth there.
4. This fourth case is the subject of our major case study in chapter 11.

NOTES AND REFERENCES TO CHAPTER EIGHT

1. Out of the original twenty seven case studies, this was the only case of electronic controls being introduced in the absence of new machinery. Normally the machine manufacturer (the supplier) would do the adding on. As we shall see, the management were able to take political advantage of this fact.
2. In this case we can hardly refer to the workers' expectations or intentions with regard to the new control system because only the skilled fitters and electricians were informed of the changes in advance. According to the general manager, the rest "just get to know", and anyway "don't really care". This does not, of course, mean that the workforce is totally acquiescent, and in the next section we will see the ways in which they were problematic from management's perspective.
3. Within the plant there is "men's work" and "women's work". Only men do the actual plating, while "the women" do the "jigging and unjigging" - i.e., attaching components to be plated to jigs with wires, so that they are ready for the plating processes (and later detaching them). This work is far more monotonous than working on the lines.
4. The works manager was quick to point out that the two who left did so of their own accord. They were simply not replaced.
5. Exactly how efficient the lines are, and will be in the future, is not known in much more detail than this. The problem is that "it depends" on so many things, not the least of them being, as we shall see, the way the platers work with the machinery. Thus an increase in

productivity is not automatically the case, and certainly the size of the productivity gains are highly problematic.

6. It is worth emphasising that management could choose the location of the computer controls because they were "adding on" to their own existing machinery. In effect they could become involved in a design process which might otherwise be carried on away from the factory. In most other case studies, once a particular machine or piece of equipment had been chosen, to some extent so had the system of control, with very important implications for the organisation of work.
7. If there are faults in the finished work - e.g., if the plate is uneven, or if the finish is dull, rectification can be difficult and costly. Occasionally whole batches of components are scrapped because their recovery would cost more than they are worth. This is especially the case with low-precision castings and pressings.
8. This problem has now been rectified simply by welding larger handles to the jigs and barrels so that the carriages can hardly miss them.
9. The platers may have a case here, for in "doing the job properly" they are achieving higher quality and lower scrap rates. Indeed, their idea of "good work" is given further credibility by reference to the chrome line. Chrome plating is far more "delicate" - i.e., the work is very susceptible to being spoiled by very slight variations in conditions (for instance, changes in temperatures or strengths of solutions). For this reason, the chrome line is not automated. The process depends on constant monitoring and frequent intervention by experienced platers, and to eliminate the present

manual control system is seen by management as impossible.

However, management's claim that lower quality and slightly higher scrap rates are tolerable on the zinc and aluminium lines if the potential productivity gains of automation are achieved is equally logical. Indeed, this may make more economic sense than the plater's idea of a good job. But detailed calculations have not been done (and probably could not be done) and the impression given is that management are now attempting to justify their political intentions (to gain control over production) by reference to an economic rationale which is far from convincing - and certainly unconvincing to the platers.

10. This is a problem, of course, only from the viewpoint of the assumptions displayed by the management - i.e., that workers "cannot be trusted" and are "unreliable", etc.
11. If management's ideas and actions have not yet appeared contradictory (and they probably have) they certainly do now. Indeed, before the move the general manager talked about the need "to attract a better class of labourer" at the same time as the need to "deskill the operators".

NOTES AND REFERENCES TO CHAPTER NINE

1. "Surfacing" refers to the making of lenses on machines which grind "blank" lenses to the shape and size prescribed by the optician. Including the supervisor and an apprentice, there are seven surfacers.
2. The actual programming for this job is highly complex, and the firm has to use a highly qualified consultant, who works in conjunction with the production manager.
3. The deskilling implications of the new methods are their most important feature, and these will be discussed below. However, as a footnote it is worth mentioning the implications for the group bonus scheme. The surfacers' bonus pay is separate from that of the rest of the factory - their bonus being related to the number of lenses they turn out each week as a group. Traditionally they have been able to control between them, through varying their effort, the amount of work they turned out, and thus their bonus. But now, especially with the current slight shortage of work, the amount they can do depends on the amount of lenses "computed" by the woman downstairs, and sent up by her to the computing room. Control of bonus pay by surfacers is now dependent on her cooperation, and so far this has been forthcoming - the surfacing section supervisor himself carrying out the necessary liaison.
4. Glazing refers to the cutting of lenses to shape, then ramming them into spectacle frames. About twenty two workers are employed in glazing. These are a mixture of men and women, whereas in surfacing, all are men.
5. Both "lining up" and "edging" are becoming simpler tasks with the latest machinery. The firm currently

has a microelectronic focimeter on trial, which in effect "reads" the lens by laser beam and does its own calculations: "there's no training needed to operate this", according to one supervisor. The edging machines are automatic, working from plastic lens shapes - i.e., depending on the shape of the frame, a plastic replica of the shape required is fitted into the machine, which then follows its contours to grind the lens to fit the frame. Operating these machines is simple enough as it is, but the firm is now considering the latest advancement, which is a microelectronic device capable of "memorising" thousands of lens shapes. When added to the automatic machines, the operator would now simply have to punch in the appropriate number, and the rest would be automatic. Apart from eliminating plastic lens selection, the cutting of new plastic replicas would be virtually eliminated, since the memory store is enormous and recall is instant.

6. There are obvious ways in which a production line's pace can be controlled, but neither mechanical pacing nor machine monitoring have been considered as possibilities. Effort was judged solely on final output, and the pace of work determined quite informally by workers themselves. (In fact what tended to happen was that towards the end of each week, production figures were considered and the bonus possibilities weighed up. By working at a steady pace, or by going faster, the workers could to some extent control the amount of bonus achieved.) Similarly, one might have expected management to take advantage of the new strategic position of the computing function in relation to the output of the surfacers. Yet there was a consideration of persuading surfacers to do some of their own computing, and even of installing computing facilities in the surfacing room itself.

7. This is not a criticism in any sense. In fact many of the "innovators" in other firms shared the same enthusiasm for technology and machinery in themselves - i.e., independently of economic considerations.

8. Job rotation is not generally practiced, however, between surfacing and glazing sections - only within them. This is mainly because surfacers have wished to hang on to their traditional position within the firm: most of the surfacers are long-serving and highly skilled in their craft, and would not take lightly to moving around the factory.

We should also mention that not only the most deskilled of the jobs were rotated. The placing of a glazer in charge of the surfacing room is an obvious example; and as this same glazer (now surfacing supervisor) pointed out, the person carrying out computing, after several months training had made her proficient, was likely to be "moved on" shortly: "...she's very good at her job now - which indicates that she'll be moved soon".

NOTES AND REFERENCES TO CHAPTER TEN

1. Or more accurately capacity is slightly higher. Recently the firm has had to impose short-time working due to falling markets.
2. To a large extent through automation, three hundred workers - by way of natural wastage and some redundancy - have been displaced between 1974 and 1980. Important though this fact is, it will be referred to only to the extent that it influences the central concerns of the research.
3. Both the manufacturing manager and technical manager pointed out that prior to introduction the concept of automation and the reasons for it ("to compete and survive the company must utilise the most efficient techniques") were explained to the workforce. Both were keen to note that there was never any dispute over the basic principles.
4. Some workers give the impression that there are separate components to "work organisation" which can be manipulated independently. This is far from empirical reality.
5. "Productionisation" refers to the process of final development and adjustment of machinery to meet the firm's peculiar needs, and to the problem of establishing the new process within the organisation. The term is not invented. It was used liberally by production management and supervision in this case study firm.
6. It was claimed to be difficult to convince the men that the new processes were far more "delicate", and mistakes far more costly. Bad habits on the old presses could be tolerated, but with the new ones "the whole process

has to be just right".

7. With injection moulding management agreed with unions that people in the loose moulding areas should be given the chance, in order of seniority (i.e., in order of length of service with the firm), to work with the new machinery. When flashless moulding came along management were "aware of the problem", but had little choice but to recruit labour on the same grounds.
8. Adjustment of this control is occasionally necessary to prevent blistering or splitting of the rubber components.
9. The question of why this group of workers were so concerned with pay is very important, particularly since otherwise negotiations could have taken an entirely different direction. This cannot be properly tackled here, but some clues may come from the facts that (i) operators were recruited according to length of service from existing "semi-skilled" areas; (ii) they were accustomed to piecework; and (iii) management never encouraged concerns other than instrumental ones. Given all this, perhaps it is hardly surprising that expectations to do with "work satisfaction", or "skill enhancement", or whatever, were never developed.
10. In this case a follow up study would be, to say the least, interesting.

NOTES AND REFERENCES TO CHAPTER ELEVEN

1. It should be emphasised that the latest round of redundancies do not represent a sudden downturn in the fortunes of the company. In fact the company took advantage of the current government's scheme of subsidising short-time working. With the subsidy running out, layoffs are inevitable. They are the result of a downturn in the market six to twelve months ago.
2. Being "skilled" is recognised by the company both in terms of status and pay differentials, and as such can hardly be expected to be attributed to, or sought by, individuals or interest groups solely on the grounds of the nature and complexity of their work. Indeed, within this plant at least, "skilled" has two meanings. Sometimes it refers to the abilities, experience, etc. of the worker, and sometimes simply to an individual's pay grade. The implications for anyone attempting to measure "skill structures" are obvious.
3. For a wider discussion of the implications of computer-controlled machine tools see chapter 5. For the purposes of this chapter we assume a basic knowledge of the nature of CNC.

Before beginning our discussion of CNC we should also mention the previous use of NC. There are five NC machines in the factory, though their designs are now quite dated. For various technical reasons they never became dominant, and have in any case now been superseded by CNC machines, which are far more appropriate to the small batches characteristic of this plant. It is worth mentioning, however, that of these five machines, only three are used as NC. On the other two the operators virtually always simply use the manual override to use them as conventional machines - a

precedent worth bearing in mind when we discuss working practices on CNC.

4. To clarify matters, by "senior managers" we mean the company's directors plus the personnel manager, and by "middle managers" we mean all other managers above the level of foreman, including superintendents.
5. Without wishing to make a finer point than the evidence allows, one might summarise by saying that the company has two breeds of manager - one careerist and mobile, the other long-serving and loyal - their discordant world views being expressed in the way they conduct their affairs. This includes, of course, their attitudes and actions towards new technology, and will prove to be relevant as the drama unfolds. The views of middle management, it should be emphasised, are difficult to see as reflections of "objective" interests, and a strong component of their views appeared to consist of a moral commitment to traditional values of skill and craftsmanship.
6. The main union is the AUEW, and a closed shop operates. The shop steward system is well organised, and although it may be inappropriate to refer to it as "strong" given the current market position of the firm, it is recognised at all levels in the firm and carries considerable influence.
7. It is tempting to criticise the short-sightedness of union policy on this count, for if they allow real skills to be degraded, their bargaining position can only suffer, putting the formal recognition of skills in jeopardy in the long term.
8. Of these nine machinists, several are not formally qualified. As with many other of the more experienced

workers in the plant, this is mainly because the early part of their working lives were around the time of the second world war, when the luxury of formal training recognised by certificates was very rare.

9. The most important status difference - that of pay - favours the machine operator rather than the programmer.
10. The office referred to is now called "Manufacturing Facilities" (an Americanism) and houses production engineers and industrial engineers, as well as programmers and planners. I was offered a desk in here, and found the place a most useful base for examining both CNC and shop scheduling - many of the most important actors being located here.
11. The indications are that as the programmers establish themselves within the Manufacturing Facilities Office, they are gaining more and more control over wider aspects of preparation for manufacture - a sort of natural job enlargement.
12. In the context of the recent redundancies due to the recession these assurances now seem rather trivial. However, if and when sales do pick up, the firm will no doubt invest in more computer-controlled equipment rather than labour, and thus in the long-run the labour-saving effects of the new technology will be realised.
13. One engineer from another firm which used this same practice of taking away the key from the control cabinet explained how operators would even go to the trouble of picking the locks to get at the controls. His conclusion was: "As long as the controls are on the shopfloor, there's no way you will keep operators off them". (this engineer is now working on the project at UMIST which will be described below.)

14. Often, when the batch is complete, the operator will make a tape recording of the programme to be stored in the office for future use.
15. It is worth commenting here that in the case of operator programming we are not talking about a simple restructuring or reallocation of the tasks "determined" by the hardware. Rather, operators are carrying out tasks which were never intended by the machine designers. Programming at the editing facility is a job which has been created by the operators, rather than simply being "taken on" by them.
16. A few more people within the firm expressed the idea that management were "taking advantage" of operators who were willing to learn programming without charging the firm for the service. However, although managers were obviously on occasions glad of the service, it is equally obvious that programmers come cheaper than skilled machinists. Besides, there was never any explicit encouragement even from middle managers.
17. The operator in this case was given two weeks of intensive instruction by the machine supplier, and has since then managed the machine on his own initiative.
18. Here I must express my thanks to Professor Howard Rosenbrock and John Boon for explaining their work during a visit to Manchester.
19. At the same time as using the machinist's skills, it is claimed that the system is an improvement on conventional CNC in terms of flexibility, efficiency and utilisation - the points on which MDI is normally criticised. See J.Boon et al., The Development of Operator Programmable NC Lathes (University of Manchester Institute of Science and Technology: Unpublished paper, 1981).

20. There may of course be some "market pull", but here we attempt no explanation as to exactly how this might work.
21. They have, on the other hand, been directly involved in changes in production control, and we will see exactly how in the next chapter.
22. This may have fortunate for the research, for there is no easier explanation for the ways people work than in terms of a cold and calculated attempt to increase their wages and decrease their effort. In the absence of the fiddle we have to see workers as moral rather than simply instrumental beings, forcing us into far more interesting areas than would otherwise be the case, and, as it turned out, far more promising areas too.

NOTES AND REFERENCES TO CHAPTER TWELVE

1. Progress clerks even have to commence work at 8 a.m. with the rest of the shopfloor, unlike other office workers who start at nine.
2. The schedulers were kind enough to allow me to actually follow them around the machine shop and the offices as they went about their work, thus allowing the build up of a detailed picture of the nature of their jobs.
3. Given all this it may appear ironic that the schedulers are using their changing jobs as a justification for upgrading to skilled status. (Previously the AUEW and management had agreed that progress clerks would remain "semi-skilled" until their jobs changed, and this is the first opportunity of regrading they have had since then.) The schedulers, however, cannot even persuade the stewards committee to represent this claim (the stewards committee wishes to maintain existing differentials) meaning they have virtually no bargaining power. The schedulers are a little bitter, describing the stewards as "doing the management's job for them".
4. Most employees in the firm - from shopfloor operators to foremen to middle management - look back on the old piecework days with some nostalgia, claiming that overall effort was far higher and remuneration much fairer.
5. One wonders whether there will be any real role left for the ratefixers to play.
6. This simple informal banking system was an "open secret" within the firm - most people knew what was going on, but no one talked about it. One can imagine the confusion I personally suffered until finding out what was

happening. This took several months, and even then the detailed workings of the kitty system remained unclear. In particular, the calculations which allowed the stewards to know when the ceiling was reached probably needed the collaboration of others - either rate-fixers or production control staff, but I can only guess the mechanisms at work.

7. My own guess, which cannot be proved in any sense, is that if the blue inspection tickets were to be used, then other information which would normally go into the central computer - i.e., information on the variance codes and times - would be omitted. Since the US parent company are to use, and possibly are using, this other information, it would be plain and obvious to them that the white work tickets were being abused in some way - either by not being completed properly, or by not being used as the information input at all. The control of bonus pay by the workers would thus be exposed to the US parents, and this would mean embarrassment for the UK management.

NOTES AND REFERENCES TO CHAPTER THIRTEEN

1. Interestingly, Blackler and Brown have made similar comments on attempts to improve the quality of working life. The lack of adequate data, and the existence of other factors which provide competing explanations for changes in labour turnover, productivity, etc. (e.g., the "Hawthorne effect"), means that the measurement of the social and economic effectiveness of job design schemes is highly problematic. See F.H.M.Blackler and C.A.Brown, Job Design and Management Control: Studies in British Leyland and Volvo (Farnborough: Saxon House, 1978), pp.61-63.
2. In several of the case study firms, some workers and lower managers questioned the value of automation of certain processes, and in many instances it would be difficult to prove them wrong on economic grounds. Occasionally managers and engineers would implicitly recognise this by allowing workers to use manual overrides (e.g., in the plating company, and in the machine tool manufacturer). In other words they acknowledged that conventional methods, in these particular cases, were more appropriate.
3. Almost invariably in the case study firms, trade unions and workers committees became involved in technical change only to the extent that the change impinged on traditional collective bargaining issues. This raises some very important questions which will be dealt with later in the conclusions.
4. Nonetheless, the ability of workers, even when unorganised, to generate opposing arguments has been demonstrated, and there is no reason why these initiatives could not be extended and formalised by workers' organ-

isations. It is also possible that workers' organisations could attempt to expose the underlying issues involved in technical change, thus bringing the real political aspects of change to the bargaining table. We will return later to these possibilities.

5. As chapter 3 pointed out, much of the literature on innovation, in using arguments about the need to remain competitive by adopting the most efficient techniques of production, is equally guilty of creating a false picture of consensus. In this sense it can serve as a management ideology or tool.
6. David F. Noble, "Social Choice in Machine Design: the Case of Automatically controlled Machine Tools" in A. Zimbalist (ed.), Case Studies in the Labour Process (New York: Monthly Review Press, 1979), pp.18-50.
7. For a brief outline of some of the alternative computer control systems for NC now available see P. Marsh, "A Fresh Start for British Machine Tools", New Scientist, 26 February 1981, pp.544-546.
8. See Mary Weir, "Are Computer Systems and Humanised Work Compatible?" in R. N. Ottaway (ed.), Humanising the Workplace (London: Croom Helm, 1977), pp.44-64.
9. Interestingly, the personnel manager (an increasingly influential figure among the top managers) was perhaps the strongest exponent of deskilling, commenting that his job would be easier if he could get the local butcher's boy or a bus driver to operate the machines with very little training, and during one interview with himself and the manufacturing director he questioned how it might be possible to use the latest equipment to achieve this.

10. It should be pointed out that only in this case was the desire of operators to have some control over their own working methods connected in any direct sense to monetary advantages, and even here one must question whether the amounts of money at stake could alone justify such serious disputes. An exploration of the reasons for such apparently unnecessary "games" is found in M. Burawoy, Manufacturing Consent: Changes in the Labour Process Under Monopoly Capitalism (Chicago: University of Chicago Press, 1979).

11. In both this case and the case of the layout of equipment in the plating company, we can see unambiguously how designs are politically informed, and how political implications are now "built into the hardware". Changing the social relations within these factories would involve changing once again the layout of the factory itself. Other examples of political qualities being incorporated into "artefacts", and a general discussion of this phenomenon, can be found in Langdon Winner, "Do Artefacts Have Politics?", Daedalus, Winter 1980, pp.121-136.

NOTES AND REFERENCES TO CHAPTER FOURTEEN

1. The fact is that if workers take to the workplace a set of skills and knowledge about the processes therein, they are more likely to attempt to exercise them. Thus, for instance, in the rubber moulding firm, where operators had spent many years as semi-skilled workers with little responsibility, it was a relatively unproblematic matter for managers to "buy off" any control which workers exercised on the new machinery. In contrast, operators in the machine manufacturing firm stubbornly refused to give up control of production in the face of pressure from programmers, their defence being based on the tradition of craft skills which they were reluctant to see squandered.
2. E.Mumford, "The Design of Work: New Approaches and New Needs" in J.E.Rijnsdorp (ed.), Case Studies in Automation Related to Humanisation of Work (Oxford: Pergamon Press, 1979), pp.9-17.
3. See for instance H.H.Rosenbrock, Automation and Society, Paper given at the workshop on "Feedback and Synthesis of Linear and Non-linear Systems", Bielefeld/Rome, 22 June to 3 July 1981.
4. That deskilling involves political and value positions was most clearly demonstrated in the case of the machine tool manufacturer, where lower managers sided with operator-initiatives to maintain control and skills in opposition to some more senior managers.
5. See for instance AUEW (TASS), Computer Technology and Employment (Manchester: National Computing Centre Publications, 1979). A review of these publications is found in K.Robins and F.Webster, New Technology: the

Trade Union Response (mimeo: forthcoming).

6. This research has already thrown up an analysis of the role of "new technology agreements" in negotiations on technology, and a discussion of their limitations can be found in R.Williams and R.Moseley, The Trade Union Response to Information Technology, Paper given to the EEC "FAST" Conference on The Information Society, Dublin, 18-20 November 1981.
7. The most recent report on the shop stewards movement shows that the recommendations of the Donovan Commission have been largely implemented, and thus that since the late 1960's both the number of shop stewards and their recognition has risen dramatically. See W.Brown (ed.), The Changing Contours of British Industrial Relations (London: Basil Blackwell, 1981).
8. Quoted D.Hull, The Shop Steward's Guide to Work Organisation (Nottingham: Spokesman, 1978), p.21.
9. In this instance the agreement represented the "buying off" of the average earnings which operators had enjoyed during the debugging and implementation of the new technology. The instance was, in fact, a reflection of the general problem of the channelling of issues into monetary considerations.
10. R.Blauner, Alienation and Freedom (Chicago: University of Chicago Press, 1964), p.185-6. Blauner's emphasis.