

THE INFORMATION PROCESSING COMPONENT

OF

JOB DESIGN

VOLUME ONE (TWO VOLUMES)

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DECLARATION

This thesis has been composed entirely by myself.

The experiment reported in Chapter 6 was carried out in collaboration with Dr. J.O.Evans of the Department of Business Studies, University of Edinburgh. Our respective contributions to this work were equal.

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- This thesis is concerned with techniques of changing the design of jobs in organisations. Current job design theories appear to be derived from four theoretical components: a theory of motivation, a model of the situation to be changed, a statement of desirable job characteristics, and a method of identifying and implementing appropriate changes. The problems of current theories appear to arise from inadequate conceptualisation of the situation to be changed. Changes in job design generally begin at the interface between managerial and non-managerial tasks and it is argued that a model of the management function is required in order to identify design options.
- A method of organisational analysis, derived from a model of organisational information processing and control, is developed, and a general theory of job and organisational design is postulated incorporating the four basic theoretical components. Emphasis is placed on provision of continuous learning as a desirable job characteristic. This theory predicts that learning is related to involvement in organisational information processing and control.
- The production control systems of two manufacturing units are analysed and the value of the model in identifying design options is demonstrated. These analyses also indicate that the transfer of information processing tasks to operators may affect several levels of the management hierarchy.
- Behaviour of conventionally structured and autonomous unstructured groups in a manufacturing simulation game are compared. The results of this experiment suggest that learning is related to involvement in information processing and control. Unstructured groups performed better, avoided some typical production management problems, and focused participants' attention on problems of organising work.
- This research indicates that existing job design theories cannot fulfil their objectives without also undertaking radical organisational design.

CHAPTER 1:INTRODUCTION.

INTRODUCTION

The Importance of Job Design

Job design has been defined as:

"...specification of the contents, methods, and relationships of jobs in order to satisfy technological and organisational requirements as well as the social and personal requirements of the job-holder." (Davis, 1966, p.21)

A number of job design techniques are now advocated which set out -

- (a) the types of characteristics that jobs should ideally have, and
- (b) ways of changing existing jobs to bring them closer to the

"ideal". The generic term for these endeavours is here taken to be "job design" and the various specific job design techniques are named and described in the text below. Job design techniques thus attempt to impose on the would-be job designer more or less rigorous methods of determining job content in organisations.

A recent survey of over 180 reported job design experiments (Birchall, 1975), illustrated the range of benefits that use of the technique has produced:

- | | |
|-----------------------|--|
| 1. System Gains | <ul style="list-style-type: none"> - improved productivity - increased efficiency - reduced costs - increased profits - improved quality - reduced inspection - improved output - reduced training costs - reduced downtime - reduced shortages - increased flexibility |
| 2. Personnel Benefits | <ul style="list-style-type: none"> - reduced labour turnover - reduced absenteeism - reduced lateness - improved work attitudes - increased commitment - fewer grievances - improved communications |

3. Worker Benefits
- increased earnings
 - improved job satisfaction

These are the aggregated results of a number of applications of job design techniques and one would not expect any particular application to produce all of these results. Nevertheless, job design techniques would appear to be fundamental to the economic performance of our country, to the effectiveness of individual organisations and to the psychological well-being of the working population. It is perhaps not surprising, therefore, that the issue of job design is attracting a good deal of attention in Britain at the moment; this may be illustrated by the following examples:

- The Government, the Confederation of British Industry and the Trades Union Congress formed a Tripartite Steering Group on Job Satisfaction in 1973 (see their booklet "Making Work More Satisfying", 1975).
- The Department of Employment established a Work Research Unit in December 1974 to direct a research programme on behalf of the Steering Group (see Jessup, 1975).
- The Administrative Staff College, Henley, has also set up a Work Research Group under the directorship of Professor Ray Wild (see the various publications of Wild and of David Birchall).
- The Industrial Training Research Unit in Cambridge is actively promoting job design projects (see Waldman and Larkcom, 1974 and Pearcey, 1976).
- The Institute of Personnel Management recently commissioned a survey of British job design practice and the results of this survey have now been

published (see Carby, 1976).

- Trade unions are now attempting to expand the terms of management-worker negotiations to include, amongst other topics, the design of jobs. The unsuccessful action of the Lucas Aerospace Combine Shop Stewards' Committee is one example of this; their "alternative company plan" dealt with changes to the company's product line, job design and treatment of employees in general. Their plan was rejected by the Lucas management in June 1976.

The Problems of Job Design

Despite the apparent potential of job design techniques, applications are not widespread. There have been a few reasonably successful applications which have been well publicised, perhaps giving the impression that the technique is more popular than is actually the case. The small extent to which the techniques have been used reflects a number of problems that are associated with the formulation and practical application of job design theories and techniques. These problems are due to a number of factors, including managerial attitudes and assumptions, institutional inertia, the influence of individual differences, the difficulties in conducting properly controlled experiments, and the difficulties in making prescriptions for job designs operational.

Managerial attitudes: Organisation structure, technology and the design of jobs are not uniquely determined by any particular set of objective factors. There is always some freedom of choice. The attitudes that management has concerning the nature of organisational functioning and the assumptions that are made about the

nature and abilities of the workforce as a whole are important determinants of the way in which organisations are structured and of the way in which individuals are given jobs to perform. Job design theorists generally expect management to alter its attitudes and assumptions regarding the nature of organisational structure and the nature and abilities of the workforce. The process of attitude change is complex and, in the case of job design, frequently unsuccessful.

Institutional inertia: Changing organisational practices and routines and the content of jobs that have operated for many years to some tolerable degree of effectiveness is not an easy process. A quantity of detailed investigation and planning is required before any change is considered; the implementation of change may have to be a gradual one taking place over a prolonged period; adequate evaluation of such changes may not be possible until a "running in" period has been completed, during which performance may fall endangering the whole project. Job design is not a simple management technique. It is difficult to implement, and for some managers it may be too difficult.

Individual differences: Most of the benefits of job design techniques are attributed to the beneficial psychological effects on the workforce of changes to job content. The spread of individual differences in the population of workers ensures that a change of job design in a given direction will not be regarded in the same light by everyone affected. Some people will welcome the novelty and the opportunities that a change in job design may offer, other people will resent such interference with a way of working that they are perfectly content with. Job design techniques are thus liable to meet resistance from both management and workers.

Experimental control: It is extremely difficult to produce unequivocal

statistical evidence that the design of jobs in a particular way is likely to produce particular results. In conducting a job design experiment in an organisational setting it is impossible to control for the influence of every possible variable that might affect the results of the experiment. "Proof" that the results of job design experiments have in fact been generated by the changes in job design is frequently based on comparatively dubious evidence such as management's opinions of the effects of the changes, or the results of job satisfaction questionnaires administered to the workers affected (and sometimes to an unaffected control group) before and after the changes take place. Frequently, beneficial results may be attributed simply to the eradication of ineffective work methods, to technical rather than to psychological changes, or to other changes taking place in the organisation at the same time as the job design experiment. To be unable to produce adequate proof that the technique being advocated does in fact work, simply exacerbates the problem of attitude change mentioned above.

Making job design prescriptions operational: It is one thing to specify that jobs should possess certain characteristics but quite another to go about changing the content of jobs so that they do in fact possess these characteristics. It is often suggested, for example, that workers should be given more "responsibility" in their jobs. A moment's thought will produce a large number of possible meanings which this term could have when being put into practice on a particular shop floor. How then does one compare the results of two experiments in which the amount of "responsibility" given to the workforce has been increased? None of the job design techniques currently available appears satisfactorily to solve this problem of turning

prescription into action.

These, then, are some of the major difficulties that beset the issue of job design. Together, they largely account for the lack of application of job design techniques. The overriding purpose of the research reported here has been to formulate solutions to some of these problems.

The Objectives of this Thesis

This thesis has two major objectives:

1. To show why the techniques currently available for designing jobs are inadequate; and
2. To derive and evaluate an approach to the design of jobs based on a model of organisational analysis.

Job design theory has foundations in academic endeavour, but however sound these are, the benefits that the technique can produce can only be achieved if a proficient method for transposing theoretical prescription into practical action is available. It is, therefore, to the problem of formulating a technique for implementing job design that this thesis is particularly directed. Current job design theories take as their unit of analysis either the individual job or groups of jobs. This thesis attempts to show that the unit of analysis that is appropriate for the implementation of job design is the organisation as a whole. Adopting this approach means that a model of organisational functioning is required, a model of the organisation as a whole that can be used as a framework for organisational analysis and change. This thesis attempts to formulate and to evaluate a general model of organisational functioning that is based on concepts taken from cybernetics and production control theory. This choice of theoretical underpinning is rooted in the assumption that "management"

as a function (rather than as a group of people) can be regarded as an information processing and control function. In arguing that this change in the unit of analysis used in the design of jobs is necessary, this thesis also argues that emphasis be placed on organisational design rather than job design. The model of organisational functioning that is developed here is used to illustrate how job content is determined by organisational design. The thesis is developed further, therefore, to specify a general theory of job and organisational design.

The Origins of this Research

The research reported here began, not as a study of job design technique, but as an investigation of management information processing procedures in organisational control systems. (The work was in fact restricted to production control systems, but the approach uses a general model of organisational information processing and control.) The project as it was originally conceived was to have been exploratory in nature and the research objectives were stated in rather general terms. Before the first part of the fieldwork was under way, however, the potential application of the model that was being developed, as a framework for job design, was realised. The fieldwork then commenced with two intentions; to investigate the nature of management information processing in production control systems, and to evaluate the information processing model used in the investigation as a framework for a theory of job design. The fieldwork involved detailed analyses of the jobs of managers - from first line supervisors upwards - concerned with production control. These analyses can be treated as studies of managerial job content.

The returns for the companies that allowed access to their personnel for the purposes of this research were not substantial. One company studied had severe production scheduling problems, a large backlog of overdue orders and consequent difficulties in quoting accurate delivery dates. The other two production units studied (both parts of the same company) suffered high rates of labour turnover, undoubtedly due to the nature of the work on the shop floor. It was suggested to the first company that an alteration to the routing of certain products through the various production stages would speed up the throughput of certain items and allow accurate delivery dates to be calculated for most products. A further suggestion - that the shop floor operators should be allowed to determine the best routing for each item - was rejected with very little discussion. None of these companies was prepared to accept that job design could provide an answer (or a partial answer) to their problems. This may have been partly due to the fact that the research was not perceived to be directly concerned with job design but with management information processing. But it is perhaps mainly attributable to managerial attitudes and to the inability of the researcher to change those attitudes.

Clarification of Terminology

There is a good deal of current interest and debate concerning what has come to be called "industrial democracy" or "worker participation". The Labour Government set up a Committee of Enquiry into Industrial Democracy (the Bullock Committee) which published its report in January 1977. The terminology of this debate has become inordinately, and unnecessarily, confused, and for the avoidance of doubt concerning the relationship between

these matters and the design of jobs, the terminology will be examined and, it is hoped, clarified before proceeding with this thesis. The terms "industrial democracy" and "worker participation" tend to be used synonymously and with little attempt at precise definition of their meaning. The term "worker participation" has always had a number of meanings. Clarke, Fatchett and Roberts (1972) for example, distinguish two basic types - "power-centred" and "task-centred" participation. The former is used to refer to arrangements that allow workers to influence management decision making at the highest level, in the boardroom. Giving workers more control over their immediate working environment, on the other hand, is referred to as task-centred participation.

Our society as a whole is run "democratically"; by analogy, it is commonly argued, society's dominant institution - industry - should be run in a similar way. But as Carole Pateman (1970) has argued, the word "democracy" does not have one definitive meaning. Rousseau, Mill and Cole took the word to mean "participative democracy"; to mean arrangements whereby everyone is involved in the process of making decisions that affect them. Current use of the word takes it to mean "representative democracy" in which a small proportion of individuals compete for the votes of the mass of the people and make decisions on their behalf as their elected representatives. The Bullock Committee is not concerned with "worker participation" (i.e. with task-centred participation or participative democracy), but with "worker representation" (i.e. with power-centred participation or representative democracy). Improved representative arrangements in industry may facilitate the introduction of desirable changes to job content, but do not in themselves affect the daily working lives of anyone except the elected

representatives and those in higher positions with whom they have to deal. What then, for example, does Carby (1976, p.63) refer to when he discusses "The industrial democracy approach to job design..."? Careful definition and use of these terms is not difficult.

Throughout this thesis, the term "job design" is used as a generic term referring to the direct manipulation of job content. It is not used to refer to forms of representative or consultative arrangements. Job design used in this sense is also a more limited form of social or organisational change than that implied by the term "participative democracy". Job design does, however, approximate to the concept of "task-centred participation", but since the latter is the more cumbersome term, it will not be used here.

The Structure of This Thesis

Immediately after this introduction, Chapter 2 presents a chronological review of the literature concerning the development of job design objectives and techniques. There are two basic approaches to the design of jobs which differ principally in the respective units of analysis that they have adopted. One approach takes as the basic unit of analysis the individual job, and is here called the "job restructuring" approach. The other approach takes the primary work group (or a department or section of an enterprise) as the basic unit of analysis and is here called the "work organisation" approach. The reason for choosing these particular terms is explained at the beginning of Chapter 2.

The development of the job restructuring approach is traced through four main "generations" from its inception in work carried out in the early 1920s. The literature has been divided in this way in an attempt to illustrate as clearly as possible the main

theoretical and practical developments that have taken place during the period covered. The work organisation approach is of comparatively more recent origin; the review of this approach begins in 1951. The review as a whole essentially covers the period 1924 to 1975. The aim of the review is to illustrate -

- (a) the general agreement between researchers (and practitioners) in this field as to which types of job characteristics are considered to be desirable; and
- (b) the difficulty that all the techniques examined appear to have in making the descriptions of desirable job characteristics operational.

It is argued that this failure to turn prescription satisfactorily into action arises in both approaches to job design through the use of inappropriate units of analysis, and that the appropriate unit of analysis for the design of jobs is the organisation as a whole. Most job design techniques advocate passing tasks that are normally carried out by management (usually first and second line supervision) to those working at the lowest level. Job design rarely concerns itself directly with managerial jobs. But it is concerned with the manipulation of managerial job content as a source of tasks that can be used to improve lower level jobs. Thus, it is at the interface between managerial and non-managerial jobs that job design typically takes place. Job design requires, therefore, some method of analysing managerial tasks.

A method of analysing managerial tasks is developed in Chapter 3. The organisational model that is described is based on a definition of management as an information processing and control function and it draws upon the theory of cybernetics and production control. The model is developed as a framework for organisational analysis

and change; it is a normative, general model of organisational information processing and control that specifies all the management tasks that an organisation must allocate to its members if it is to function effectively. It is not simply a method for the descriptive analysis of organisational functioning, although it can be used as such. As a normative model, it shows how an organisation should function if it is to be effective, rather than how any particular organisation does function.* The model itself says nothing about how the tasks specified should be allocated to members of the organisation, but the job designer with such a comprehensive specification is in an excellent position from which to begin allocating tasks in the manner considered to be most desirable. This is, then, a framework for organisational design as much as a framework for job design. The model is a general one and can be applied to any type of organisation of any size.

The general model of organisational control described in Chapter 3 has functional properties in common with theories of human learning that are based on cybernetic concepts. Chapter 4 illustrates how this similarity may be exploited in order to operationalise "desirable job characteristics" - the provision of continuous learning and feedback of performance results in particular. Chapter 4 also illustrates how other desirable job characteristics can be made operational using the model of organisational control, and a general theory of job and organisational design is developed combining the model of organisational control and cybernetic models of human learning. This theory shows how organisational and job design

* The word "normative" is used throughout in the sense indicated in this sentence.

changes can produce work in which participants can learn to improve their performance, either by improving their performance of specific tasks, or by rearranging and reallocating tasks amongst participants to improve overall performance. If those performing jobs are allowed to change the design of those jobs, this raises the question of what is "designed" in the first place. It is argued that jobs as such should not be designed at all, but that the method by which their design is determined should be designed. The determination of job content is a part of the management function. Having designed this function and handed it over to those who perform the non-managerial jobs, there is no need to design the non-managerial jobs as their content will now be determined by the managerial function. Job and organisational design, therefore, become the design of information processing and control systems.

The production control systems of three manufacturing units were studied using the model of organisational control as a framework for analysis. The results of two of these analyses are presented in Chapter 5. These analyses can be regarded as studies of managerial job content and they are used to illustrate how job and organisational design choices can be generated through such an analysis. The analysis produces three types of information:

1. It specifies the content of existing managerial jobs, throughout the production control system, and their inter-relationships.
2. It indicates control system operations that are not being carried out effectively, or that are not being carried out at all.
3. It provides a comprehensive framework for the reallocation of tasks throughout the organisation, i.e. it provides a framework of change for job and organisational design.

It was not possible to obtain permission from a local company to manipulate job content along lines suggested by the model. Chapter 6 describes a moderately successful attempt to test some of the hypotheses generated from Chapter 4, within the confines of a laboratory experiment. Two versions of a production system simulation game were designed and used on a number of production management courses run by the University of Edinburgh, Department of Business Studies. (This resolved the problem of obtaining sufficient participants.) One version of the game simulated a conventional production control system with a typical information system; the other version simulated a production system controlled "democratically" (in the participative sense) by its members who were asked to use a modified information system.

In terms of overall performance (measured by a number of criteria) and "learning about production management" (measured by content analysis of participants' essays) the "experimental" groups performed significantly better than the "standard" groups, bearing out the general predictions of the theory. The "learning" that took place in the experimental groups, however, was not quite as predicted. It was assumed that both game designs would confront participants with essentially the same problems, but to different degrees. But the experimental design appears to overcome some conventional production management problems, and participants in these groups faced problems that were different from those met by the standard groups. The statistical evidence upon which this inference is based, however, should be regarded with due scepticism. Many of the results are derived from the content analysis of short essays, and while every attempt was made to conduct this analysis

in a rigorous manner, the resultant categorisation of content is subjective. This must be taken into account in interpreting the statistical evidence that is presented.

A brief summary of the research, arguments and conclusions described in Chapters 2 to 6 is given in Chapter 7. An attempt is made in this Chapter to evaluate the success of this research in meeting its stated objectives, i.e. in identifying the problems of current job design theory and its implementation, and in the formulation and evaluation of an alternative approach to the design of jobs that overcomes these problems.

Appendix I presents two additional case studies of production control systems, in two "common ownership" companies. The analysis of their control systems is conducted using the general model of organisational control described in Chapter 3. These studies indicate a degree of confusion over the meaning of the term "workers' control". In one of these companies the workforce do control their own work, taking all decisions affecting the company's operations as a group. Only a small company can do this, and this one has eleven employees. In the other company studied, the workers operate under a conventional hierarchical management structure. They each have a proportion of shares in the company (there are no outside shareholders), the amount depending on the length of time they have been working there. This could be described as "workers' ownership", but in the management of the company, the workers have no control at all.

Appendix II contains detailed descriptions of the designs of the two versions of the production system simulation game and of the manner in which these games were run. This experiment produced three sets of results. The full analysis of these results is also contained

in Appendix II.

Appendix III contains various supplementary materials used in the simulation games, such as the game Umpires' instructions and the paperwork that was used in each version of the game.

Appendix IV contains a further case study that supports the evidence presented in Chapter 5, and an example of how this type of information was obtained is also included here.

CHAPTER 2:

THE DEVELOPMENT OF JOB DESIGN OBJECTIVES
AND TECHNIQUES.

THE DEVELOPMENT OF JOB DESIGN OBJECTIVES AND TECHNIQUESIntroduction

The material dealt with in this Chapter covers ground which has been trodden, and in some cases heavily trampled, by numerous authors who have not necessarily concerned themselves directly with the design of jobs. This is an indication of the multi-disciplinary nature of the relevant work. Job design theory has been dependent upon a number of disciplines for its development such as psychology, sociology, social psychology, economics, production engineering and systems theory. This Chapter is principally concerned with job design objectives and techniques and it is not proposed to present reviews of the development of admittedly closely related topics such as job satisfaction and the motivation to work, although it will be necessary to point to a quantity of work from these areas which has particular relevance to job design theory.

There are currently two conceptually distinct approaches to the design of jobs; one approach based on the analysis of individual job content, and the more recently developed approach concerning the manner in which work as a whole is organised. A further distinction which may be drawn between these approaches is that they were developed and are currently being applied on opposite sides of the Atlantic, the former in North America, the latter in Europe, particularly Scandinavia.

Davis and Taylor (1972) call these approaches "job-centred studies" and "work-system studies" respectively; Herzberg (1974) makes the distinction between "orthodox job enrichment" and "social job design approaches"; Wild (1973, 1974a) refers to "job and work changes" and "organisational changes". Any confusion

implied by this variety of terms is more apparent than real, the disagreement is over what the approaches should be called, not what they entail. The labels considered most apt and adopted here are those used by Wild (1975) whose complete categorisation scheme is shown in Figure 2.1, p.36. He uses the terms "job restructuring" and "work organisation" which appear to summarise concisely and accurately the somewhat diverse content subsumed under each heading.

Generally speaking, the techniques of job restructuring were the first to appear, and are dealt with first here. As will be seen, early writers frequently advocated job rotation, now regarded as a "work organisation" development; it is, however, included without comment below in the job restructuring section partly because of the time of its introduction in the literature, and partly because the major form of work organisation development concerns "socio-technical system design" and the concept of the "autonomous group". Job rotation is sometimes implied in autonomous group working, but the latter generally involves more dramatic organisational changes than the original exponents of job rotation conceived. Wild's categorisation is explained in more detail below, p.238.

1. PROLOGUE

Industrial Engineers

It is customary for anyone now writing about the relationship between man and work to begin by presenting the "scientific management" theories developed in America during the late nineteenth and early twentieth centuries. Due to the vast amount of discussion and criticism of this work already in existence only a

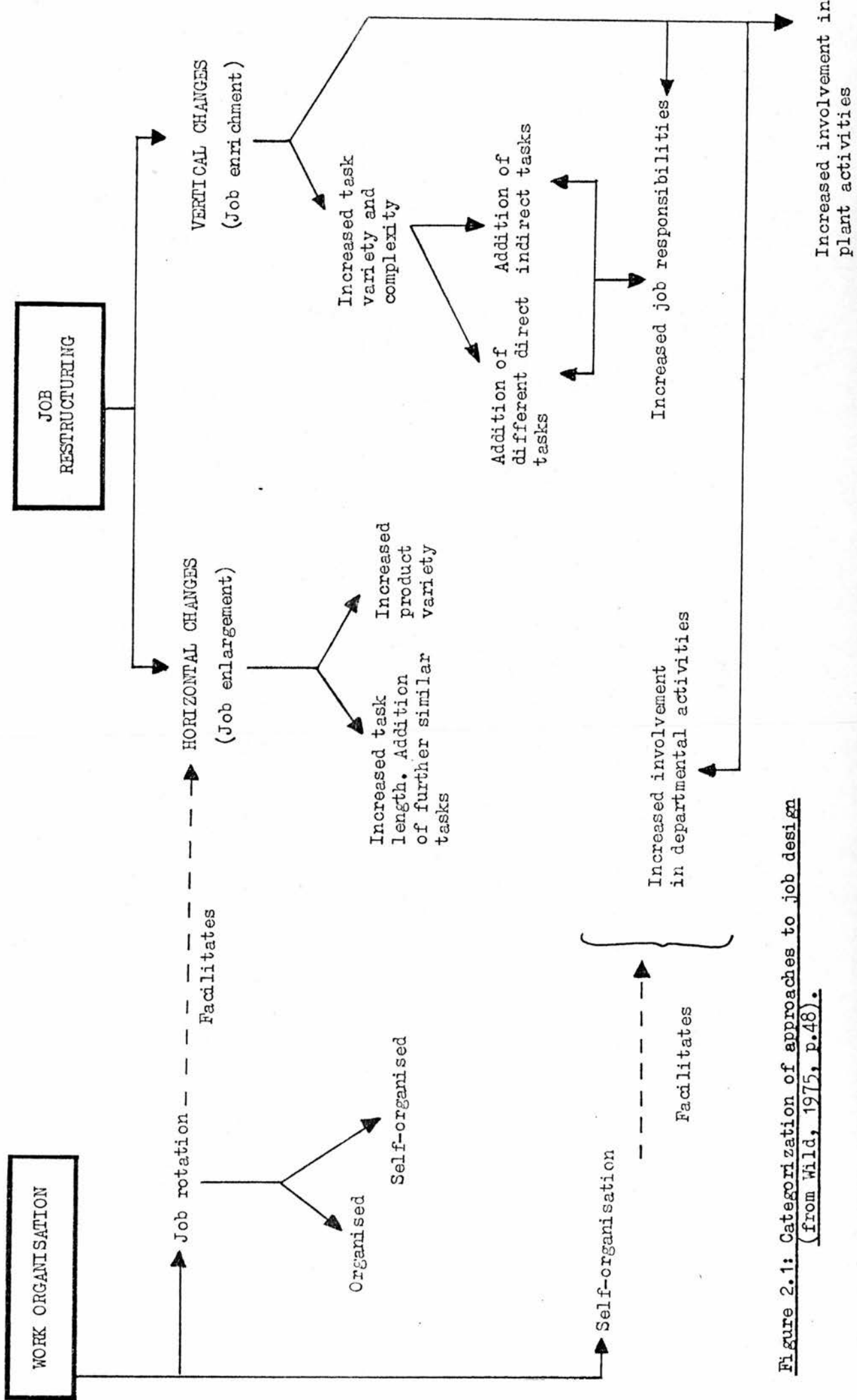


Figure 2.1: Categorization of approaches to job design (from Wild, 1975, p.48).

brief account will be given here, necessitated by one common objective of modern job design theories - to replace those advanced by the scientific management school. The originator of these theories was F.W. (Speedy) Taylor, whose pronouncements are to be found in his two major publications, "The Principles of Scientific Management" and "Shop Management", both of which first appeared in 1911. In these works, Taylor expounded theories of organisation structure, task design and worker motivation all of which are now regarded as grossly inaccurate. His colleagues and subsequent followers, notably F. and L. Gilbreth (initiators of "time and motion study") and Charles Bedeaux, were to develop and modify his ideas but left the fundamental principles intact. Leaving aside Taylor's influential ideas concerning organisation structure and "functional management", his methods of task design and theories of worker motivation are of more interest here.

Taylor advocated two forms of division of labour, between managers and workers, and between members of the productive workforce. Managers should concentrate solely on "brain work" and the workers should perform only the "spade work" (or in the case of the Dutch pig-iron handler Schmidt, "shovel work"). There should be no overlap, workers being explicitly informed that they were not paid to think, that this was management's job. Manual work, argued Taylor, should be divided into small, easily learned units so that the worker could quickly become "expert" at his particular task. Part of the "science" came in determining the "one best way" in which to perform these units, minimising unnecessary movement through careful analysis of the task components, and reducing fatigue still further with judiciously spaced rest periods.

Once the one best way is determined, the worker is expressly forbidden to deviate from the given work methods.

Taylor did have dramatic success in improving productivity using these methods, but his search for efficiency was regarded by many who came in contact with it as a depressing and degrading affair. Taylor always stressed that his task design methods would only be effective if used in conjunction with a "scientifically" designed piece rate incentive system. He regarded workers as intrinsically lazy and if they were to agree to perform their tasks his way, this would only be due to the promise of increased financial reward.

At least two points may be made in mitigation of Taylor's work, given the burden of criticism which it has had to bear. First, the managerial methods advocated were regarded as admirable solutions to the problems of American industrial society around the turn of the century. Industrialisation and mechanisation were proceeding apace, and the availability of large amounts of unskilled immigrant labour enhanced the attractions of Taylor's task design methods. Unskilled and unorganised, first-generation immigrants experienced language difficulties and had no desire for control over their work situation; so long as the work was adequately paid, task specialisation was desirable and necessary. Second, in explaining these techniques more or less systematically, he influenced to a great extent the areas of investigation in which later students were to work, and provided a theoretical framework (however shaky) against which contradictory ideas could be formulated and clarified. Very much a product of his time, Taylor's work continued to stimulate research long after his death.

In practice, these theories have proved remarkably resistant to change. Future students may point to the delay of over half a century or more between the production of convincing proof of the inadequacy of their assumptions and techniques, and the beginnings of change in organisational settings on a meaningful scale. Surveying the job design methods of two dozen American companies, Davis, Canter and Hoffman (1955) found that tasks were combined into jobs in order to maximise specialisation, reduce variety and make the work as repetitive as possible in order to minimise training time; exactly what Taylor suggested. In the course of the well known "South Essex" studies, Woodward (1965) encountered two companies using a form of Taylor's functional organisation. His views on worker motivation and the incentive power of money are widely shared in British industry to this day and should require no example. Scientific management has thus proved to be a popular and persistent ideology which has managed to withstand practically unanimous academic opprobrium due to its palpable success in practice. There are, however, signs that this apparent immunity is neither impregnable nor permanent; as investigation and experience continue to reveal the dysfunctional side-effects of task fragmentation, and as the interest of management and government in techniques of job design and worker participation continues to grow.

Although numerous companies in America, Britain and Europe eagerly implemented his methods, Taylor frequently had to contend with argument from management and workers alike in his attempts to implement the "Taylor system" (a term supplied by others, but which he personally deplored as it detracted from the "scientific" essence

of the technique). He never actually managed to apply scientific management in full at Bethlehem Steel, the company with which his name is frequently associated probably because that was where he discovered his protégé Schmidt, the inefficient pig-iron handler. Bethlehem fired Taylor in 1901 after his persistent conflict with the management. Further setback was to come with the Watertown Arsenal strike in 1912 which was a direct result of the implementation of Taylor's methods. The strike prompted an investigation by a Special Committee of the House of Representatives, and later unrest at the Arsenal prompted a further inquiry in 1914 by the United States Commission on Industrial Relations.

The first truly "scientific" investigations of Taylor's ideas, however, began several years after his death in 1917, and these took place not in America but in Britain. It is with these initial investigations that this review properly begins. They are called "scientific" because they were conducted by people trained in the theory and research methods of the experimental psychology of that time. They called themselves "industrial psychologists" and although they did carry out some laboratory work in this area, the majority of their studies took place in industrial settings. The year in which this review starts is 1924; this is a convenient date being the year in which the first (British) Industrial Fatigue Research Board report concerning the problems of repetitive work was published, and the (American) Hawthorne studies dealt with briefly below got under way in Chicago.

2. JOB RESTRUCTURING

British Industrial Psychologists

The Industrial Fatigue Research Board (IFRB) was established in

1918 principally to continue the work of the Health of Munitions Workers Committee conducted during the First World War. The name was changed to Industrial Health Research Board (IHRB) in 1929, reflecting the changing and broadening emphasis and directions in its work. In contrast to earlier work on the problems and alleviation of worker fatigue, the IFRB launched in 1924 a series of studies of a related, but distinctly different problem: monotony and the unit of work or work cycle.

Several types of light, short cycle repetitive work were studied in different factories and their effect on productivity and worker attitudes examined. Repetitive work was generally found to be boring, leading to systematic reductions in output. Taylor advocated task specialisation which created repetitive work, and the obvious antidote to repetitiveness was variety.

In a number of short cycle operations Vernon, Wyatt and Ogden (1924) found that workers introduced variety into their tasks themselves, either by doing other tasks, moving around or resting. The type of tasks studied were:

in the boot and shoe industry -

- women stitching boot and shoe uppers, 1 minute work cycle;
- men stamping pieces of leather to be built up into heels, 1 to 4 seconds cycle;
- men building heels, 30 seconds cycle.

and in the tin canister industry -

- women inserting linoleum and cardboard discs into tin caps, 1 second cycle;
- stamping out tin lids, 0.7 second cycle.

Job rotation was found to increase both variety and output:

"When the form of activity is changed at intervals of approximately half an hour, an increase in output of 17 to 20 per cent was observed in the case of two operatives". (p.36)

A large number of changes in the course of the working day had an adverse effect on production. It is significant that job rotation is advocated in this report despite the fact that the highest output in this experiment was achieved with the two operatives mentioned working constantly, at the same task;

"... but the days of uniform activity were much disliked by the operatives". (p. 36)

So the long-term effects of repetitive work were thought to be substantially different from the short-term effects. It was suggested that an optimum duration could be found for each worker and for each kind of work after which it would be desirable to rotate to another activity. These results were a direct challenge to the prescriptions of scientific management and further studies produced confirmatory results.

Wyatt, Fraser and Stock (1928) observed women wrapping soap, folding handkerchiefs, making bicycle chains, weighing and wrapping tobacco, making cigarettes and assembling cartridge cases; again all light repetitive tasks. Output was lower and more irregular with uniform than with more varied work, changes of activity every $1\frac{1}{2}$ to 2 hours being most effective.

Representing something of a departure from their previous research methods, Wyatt, Fraser and Stock (1929) adopted the less rigorous approach of asking 49 workers for their subjective opinions of their work. Boredom was found to be a common characteristic of repetitive work; less than one third of their sample claimed

that they never experienced boredom. The experience of boredom was also found to be associated with lower production and fluctuations in work rate. The authors suggested that as bored workers apparently overestimate time intervals, the working day seems longer and they reduce their work rate accordingly! More significantly, boredom was seen to be related to degree of task mechanisation. Completely mechanised tasks allow the worker to daydream or converse with other workers, and work which is completely absorbing similarly precludes boredom. It was in the semi-automatic processes that boredom was found to be most prevalent. From this particular study came a number of conclusions which appear in much subsequent research:

1. Repetitive work is associated with the mechanisation of production; the experience of boredom at such tasks has psychological effects on the worker and adversely affects output. Fatigue and boredom are regarded as distinctly separate phenomena.
2. The mediating effect of individual differences on the experience and toleration of boredom is recognised, workers of higher intelligence apparently becoming bored more quickly.
3. The concept of "habituation" is outlined (although this term is not used):

"Continuous exposure to monotonous conditions of work causes adaptation to such conditions so that work which initially is tedious and unpleasant may afterwards be tolerated or even mildly enjoyed".
(Wyatt, Fraser and Stock, 1929, p.43)
4. The social conditions of work were found to have significant (but not emphasised) consequences, boredom being less likely

to arise:

".... when the operatives are allowed to work in compact social groups rather than as isolated units".
(p.43)

Task specialisation could thus perhaps produce improved results in the short term, but it was now clear that the boredom induced by such work more than offset any of its advantages. Suggestions for counteracting boredom included increasing opportunities to alter posture, spaced rest periods, grouping workers so that conversation is facilitated, job rotation and even the broadcasting of music during work spells (Wyatt, Frost and Stock, 1934). This latter idea was tested experimentally, and output was mysteriously highest when music was played for 75 minutes at the middle of the work spell (Wyatt, Langdon and Stock, 1937). The female operators concerned, however, preferred to listen to it during alternate half hour bursts throughout the day. (United Biscuits currently spend between £70,000 and £90,000 per annum maintaining a radio station broadcasting over G.P.O. land line to their factories all over the country: Albert, 1974.)

As toleration of boredom varied with individual differences, it is natural that improved selection procedures should be advocated, to screen out workers more likely to find repetitive work intolerable (Wyatt, Langdon and Stock, 1937). Further work by the IHRB in this area produced similar results and offered similar solutions to the problems of machine paced, repetitive work, the main ones being job rotation and improved selection methods. These are, however, indirect solutions and it was the work of the National Institute of Industrial Psychology (NIIP) which advanced these findings into the area of job design.

The NIIP had been established in 1921, due largely to the efforts of the influential C.S. Myers who became its director and who was also a member of the Committee on Industrial Psychology at the IFRB. Dependent upon consultancy fees for its existence, obvious constraints were placed on the Institute's choice of research activities and the publication of results. There was some concern with the repetitive work problem, indicated in one short report of part of a large scale investigation of assembly methods at a company manufacturing wireless sets, Kolster-Brandes, Ltd., (Harding, 1931). The experiment reported lasted for three weeks and involved two operators (one of whom "... had to be dismissed on the (third) Wednesday."). Performance at a "small" work unit was compared with that on a "large" unit. These two work units comprised, respectively, soldering either two or three wires to each set, or eight to eleven wires. Harding's concern was to find the optimum size of work unit. Initially, performance on the small task was better, but this improvement was not persistent; the workers preferred the larger task and performance at it was still improving when the experiment was discontinued. These results are consistent with the earlier results concerning the introduction of variety through job rotation, but here the tasks themselves were changed (in a minor way) rather than the workers' allocation to tasks. Harding did not use the term, but this appears to be the first report of a "job enlargement" experiment, albeit a comparatively small scale one.

The Industrial Health Research Board was disbanded in 1947, and Wyatt became director of the Medical Research Council Group for Research in Industrial Psychology. From within that group,

Walker and Marriott (1951) and Wyatt and Marriott (1956) published the results of an attitude survey of 174 car and metal mill production workers. Job satisfaction was found to be highest amongst workers in jobs having not only variety but also requiring some measure of skill and having opportunity for pride in achievement. Satisfaction was found to be correspondingly lowest with workers on simple repetitive tasks. Researchers from the NIIP continuing this line of research predicted difficulties in persuading management to allow experimentation with varying work content, but some managements had by this time recognised the problems of repetitive work for themselves and many corporate member firms of the Institute welcomed the opportunity to contribute to their investigation. Cox and Dyce Sharp (1951) explored Harding's (1931) suggestion that an optimal work cycle could be found. Discussing the results of ten field experiments concerning the effects of work cycle and batch size on job satisfaction and productive efficiency, a number of conclusions were presented:

(a) Operators learning a task prefer small batch sizes; experienced operators should be given batches lasting 1 to $1\frac{1}{2}$ hours.

(b) A longer work cycle can increase output and quality.

Two examples are given:

(i) the average output and quality produced by one girl assembling a hearing aid, with a 20 minute work cycle, were higher than for a ten girl assembly line working on the same product;

- (ii) in lingerie manufacture, reduction in team size from 6 to 4, and consequent increase in work cycle, raised output to 43 per cent above its original level.
- (c) lengthening the work cycle reduces problems of line balancing; through the build up of buffer stocks, individual operators can vary their work rate without affecting others.
- (d) operators should have the opportunity to vary the task, e.g. the sequence of operations or the batch size. This increased freedom improves job satisfaction, output and quality.
- (e) lengthening the work cycle provides a more "meaningful" job.
- (f) training of operators experienced in small work units to perform large work units is quite feasible.
- (g) the rhythm of the flow of work is for some a source of satisfaction in repetitive work, and continuity should wherever possible be maintained. (Baldamus (1951) referred to this phenomenon as "traction".)

In theory at least, therefore, the notions of task specialisation and the "one best way" were shown to be dysfunctional, and by the early 1950's an advance had been made by adding to the term "variety" as the antidote to repetitiveness (variety principally implying job rotation), job enlargement and increased operator responsibility for his work. These developing ideas concerning the relationship of man to work went naturally hand in hand with administrative and economic benefits. Job enlargement could alleviate some work flow scheduling difficulties as well as reducing monotony and improving output and quality. Taylor's view of the worker as a machine driven by money had to be replaced with a more complex

model indicating the relationships between task characteristics, individual differences, job satisfaction, and performance. Research in Britain at this time was due to take off on a rather different tack, and until part 3 below ("Work Organisation") where those developments are taken up, almost all the research mentioned is American.

During the period with which we have been dealing up to now, American industrial psychologists were mainly preoccupied with the application of psychology to advertising, and with devising personnel selection tests. The first large scale applications of the findings discussed above and their implications, however, took place in America towards the end of the Second World War. The initiative for this work came not from the earlier British research, but mainly from managements acting on their own intuitions with regard to the problems raised by their job design practices. Academic involvement generally commenced once projects were under way. Before turning to those experiments, a brief sketch of a related facet of American research from the 1920's to the early 1940's is given, not because it directly concerns job design but because it instigated a somewhat dramatic revision of the way in which man at work had come to be regarded.

American Industrial Sociologists

The infamous "Hawthorne Studies" which began in 1924 at the Chicago factory of the Western Electric Company attempted initially to examine the relationship between output and illumination. No such relationship was found. The intended results of these experiments were to have been the kind which appear as profits in

company accounts, not as papers in academic journals, and the experiments were at first carried out by a research division within Western Electric. The Harvard Business School, however, became involved from 1927 onwards.

The precise nature of this research and the results are matters which need not detain us here, and which must in any case now be regarded as equivocal. Accounts are to be found in Roethlisberger and Dickson (1939) and Whitehead (1938), and in the various writings of Elton Mayo who had little to do with the actual running of the experiments but who acted as something of a publicity agent for the findings. The research methodology and interpretation of the results of the Hawthorne studies have been subjected to a mass of criticism and re-evaluation. Carey (1967) for example argues that the results provide confirmation of the influence of financial incentives on output and the efficacy of authoritarian leadership, points which the original researchers had claimed to have been largely disproved. Blumberg (1968) claims that these should really be regarded as experiments in worker participation due to the extent of consultation which took place before any experimental changes took place.

The immediate impact of this work was in constructing a theory of management based on the "rediscovery" of two subsidiary findings of the earlier British industrial psychologists: that workers improve their performance when someone (even a researcher) takes an interest in what they are doing (Vernon, Wyatt and Ogden, 1924, p.15); and that the opportunity to interact freely with other workers boosts morale. The researchers emphasised the distinction between "formal" and "informal" organisation of workers

and the relationships between informal organisation and performance. The resultant "human relations" school of management emphasised the importance of the work group - Taylor's worker required only money, the human relations school's worker required group membership. The counselling programme at Western Electric indicated the importance of supervisory style in the handling of work groups, and this became a major area of research for American industrial psychologists, inspired largely by the work of Kurt Lewin and his associates. Changing leadership style is not job redesign and this line of research is not directly relevant here. The realisation of the importance of the work group on the other hand is a topic to which much attention is devoted below.

First Generation Theory : Job Enlargement Advocates

During the Second World War, American industry seems to have become more acutely aware of the implications of job and organisational design for productivity and associated costs (Drucker, 1946). One critic of the human relations movement, Robert Merton (a sociologist at Columbia University), was very much aware of the "social repercussions of technological change", one of which would be to "affect the network of social relations among workers engaged in production" (Merton, 1947, p.79). He saw technological change enforcing obsolescence of skills, loss of public identity in particular jobs through increased specialisation and creating increased workplace discipline. In this paper (which was about 25 years in advance of its time) Merton also discusses the political implications of technology

which could be used ".... as a weapon for subduing the worker by promising to displace him unless he accepts proffered terms of employment" (p.80). (For a more extensive contemporary treatment of this point, see Dickson, 1971.) Merton thus makes a common criticism of Mayo's sociology, that it is concerned with what goes on in the individual factory; it focuses on "plant life" while disregarding what is taking place in the garden as a whole. Merton's caution over the limitations of a research approach devoted solely to either the immediate work situation or to the larger social structure went largely unheeded, at least where job enlargement was concerned. One job enlargement advocate did note that social characteristics of work groups influenced their attitudes to work and affected morale which was generally lower amongst workers from metropolitan backgrounds than those from rural areas (Worthy, 1950, p.173).

The basic argument for job enlargement ignored such complications. Morris Viteles, then Professor of Psychology at the University of Pennsylvania, outlined the argument as follows, and although it will be seen to have been derived from earlier British research, Viteles was able to cite some similar American research including Walker's (1950) case study described below.

Increasing mechanisation of production, Viteles argued, creates specialised repetitive tasks at which a large proportion of people experience monotony and boredom. The experience of boredom has an adverse effect on output and work rate, produces a higher number of complaints, and generally reduces morale. Factory rules are ignored and absenteeism and turnover increase. Selection should



screen out those unlikely to tolerate monotony, but since the root cause is in the nature of the task, job variety should be increased. This can be done through job rotation and job enlargement. (See Viteles, 1950; and for a restatement of the same argument twelve years later, Stephens, 1962.)

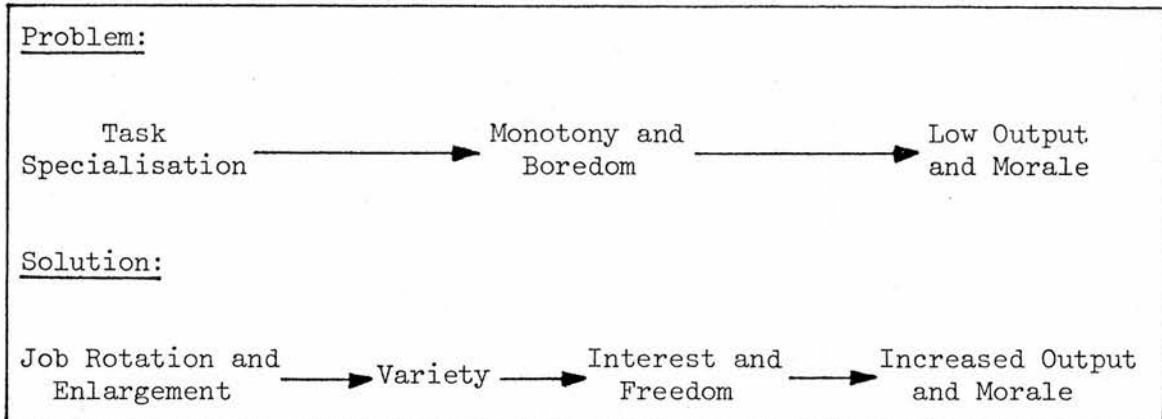


Figure 2.2 : First Generation Theory (Viteles, 1950).

What are described here as first generation theories have the somewhat simplified argument of Figure 2.2 in common, and research was directed at obtaining a deeper understanding of the links in this causal chain. One major investigation of the relationship between technology and workers' job experience was conducted by Walker and Guest from Yale University whose work "The Man on the Assembly Line" (Walker and Guest, 1952) made an important contribution to this area. (See also Walker, 1954, and Guest, 1955, for brief summaries of the major work.) In their attitude survey of 180 automobile assembly workers, six characteristics of mass production work were identified:

- "(1) Mechanical pacing of work
- (2) Repetitiveness
- (3) Minimum skill requirement
- (4) Predetermination in the use of tools and techniques

(5) Minute subdivision of product worked on

(6) Surface mental attention." (p.12)

Jobs were scored in terms of these characteristics, and while the workers were found to be satisfied with pay and conditions, workers on jobs with a "high mass production score" exhibited a higher absenteeism rate than those on jobs with lower scores (p.121). They suggest that the undesirable characteristics of mass production work can be improved by job rotation and enlargement (p.148). Thus, although the solutions are the same, the problem is seen as a somewhat more complex one with task characteristics other than specialisation and repetitiveness (or rather derived from these characteristics) seen to be important, e.g. the extent to which the worker's abilities are utilised, how much control over work methods he has, and how meaningful the task is to him. Nancy Morse (Survey Research Center, University of Michigan) claimed to have found a similar predilection for work involving skill, variety and decision making amongst a large sample of (over 700) young female white collar workers (Morse, 1953).

Working at Yale University with C.R. Walker, but researching in another plant, A.N. Turner's attitude survey of over 200 "longer service" auto assembly line workers indicated that both the job and supervision affected worker morale (Turner, 1955 a). It should be the task of the Foreman, therefore, to reduce the pressure on workers created by mechanical pacing, and the "feelings of impersonality" induced by task repetitiveness. Apart from the "human relations" nostrums such as "establishing with each one a personal relationship apart from the job relationship",

Turner also suggested that the Foreman permit job rotation and other methods of increasing variety in the work (Turner, 1955b, p.44).

Existing in harmony with, but not a central facet of the human relations movement, job enlargement theory was well established in America by the mid 1950's, and as the next section illustrates was also fairly well established in practice.

First Generation Theory : Job Enlargement in Practice

In America in the early 1950's, job enlargement projects were carried out in a number of different industrial settings, six of which are mentioned here. Viteles (1950) gives an example of a job rotation scheme, but these do not appear often in the literature. This is undoubtedly a poor indicator of the extent of application in practice since job rotation, involving no alteration to specific tasks, is easily undertaken where simple repetitive work is concerned. The focus here, then, is exclusively on job enlargement.

It is generally accepted that the first true job enlargement project is that reported by C.R. Walker in 1950. The changes were permanent and affected a substantial number of workers ("several hundred") in contrast to Harding's previous experiment described above. The project was conducted in the Manufacturing Department of IBM's Endicott Plant on the initiative of the Chairman of the Board, and it began in 1944 :

"Machine operators began in that year to make their own 'set-ups' and do their own inspection. In other words, their jobs were enlarged to include the skills and responsibilities of 'set-up' men and of inspectors." (Richardson and Walker, 1948, footnote on p.12.)

In a well known paper in the Harvard Business Review, Walker (1950)

gives a detailed account of the job enlargement changes made at Endicott. He gives no specific definition of the term, but makes reference to "... enlarging and enriching the basic content of the jobs" (p.54), and to ".... enriching the job in variety, interest and significance" (p.55). (A more detailed definition is given in "The Man on the Assembly Line":

"Job enlargement is simply the recombining of two or more separate jobs into one This means a lengthening of time cycles." (Walker and Guest, 1952, p.151))

From the beginning, therefore, job enlargement was a comparatively simple ad hoc antidote to the adverse effects of task specialisation. The benefits of task recombination appeared to have been improved product quality and a reduction in losses from scrap, less idle time for men and machines, and a reduction of 95 per cent in set-up and inspection costs.

The apparent simplicity of this initial application of the technique and its effects is dispelled, however, by a reading of the full account of the company's organisational changes between 1940 and 1947 given in Richardson and Walker's (1948) "Human Relations in an Expanding Company." The job enlargement changes were only part of a comprehensive organisational development programme which took place over seven years. The authors list a number of "non-typical changes in organisation" from this period. Total plant personnel almost doubled, the machining section increased by 147 per cent and "educational" staff by 450 per cent. (Chapter 1.) There was a reduction in the number of hierarchical levels of authority from 6 to 4, and there was also a reduction in supervisory span of control. Not only operators had their jobs enlarged; a similar policy for foremen began in 1940 with the

elimination of assistant foremen and keymen ("strawbosses"). Foremen were also given a number of functions previously carried out by the Personnel Department, such as handling grievances. (Chapters 2 and 3.) In addition, major changes were made to the workflow system. Basically, the job lot manufacturing operation was replaced by a "progressive assembly line"; this meant that parts no longer returned to the central store after each operation had been completed but continued directly to the next section and the next operation. The previous system had entailed "multiple handling" of all parts and the new system speeded up throughput, greatly simplified the paperwork, and virtually eliminated production hold-ups. (Chapter 4.) This had the additional advantage of reducing the "... human fret, fatigue and frustration" (p.80) characteristic of the old system.

Numerous other changes which took place included :

- the abolition of piecework in 1936 (p.13);
- an above national average rate of wage increases (p.28);
- additional "employee benefits" (p.28);
- weekly supervisory meetings (p.45);
- the establishment of a Workers' Advisory Committee (p.45);
- the education section started running courses for supervisory personnel, from 1940, in a range of subjects from cost analysis to human relations (p.46).

The benefits attributed to job enlargement (with the exception of reduced set-up and inspection costs), therefore, could equally plausibly be attributed to various combinations of these additional factors. The two most important are probably the reduction in frustration through improvements in work flow, and increased training

and responsibilities (i.e. job enlargement) for first line supervision. As a job enlargement "experiment" it was completely uncontrolled and has been dealt with here in some detail as other similar case studies are open to the same type of criticism. This lack of methodological rigour, either in introducing the changes or presenting the results, did not prevent uncritical acceptance of the technique by others who cited this study as a model for other applications.

Subsequent applications of the job enlargement technique involved clerks, typists and supervisors at Detroit Edison (Elliot, 1953*); operators painting wooden toys at Hovey and Beard (Strauss, 1955); accounting clerks at Colonial Insurance (Guest, 1957a*); assembly line operators at a hospital equipment manufacturers (Guest, 1957b*); and sales clerks at Richardson, Bellows, Henry and Company (Chain Stores) (Krugman, 1957). These reports are anecdotal in style and only that of Marks (see footnote) appears to have been conducted with any attempt at experimental control. Bearing in mind that these studies all took place on managerial, not academic, initiative, the technique attempted to solve the following problems :

- high absenteeism (Strauss, 1955);
- high labour turnover (Strauss, 1955; Guest, 1957a; Krugman, 1957);

* Reports of these case studies can also be found in Walker, 1962, pp.119-135. The second case study attributed to Guest (1957b) was actually carried out by A.R.N. Marks, "An investigation of modifications of job design in an industrial situation and their effects on some measures of economic productivity", unpublished doctoral thesis, University of California, Berkely, 1954. More detailed accounts of Marks' study can be found in Davis and Canter, 1956, pp.278-280, and Davis, 1957b, pp.176-178.

- poor quality work (Strauss, 1955; Guest, 1957a);
- problems of work flow scheduling (Elliot, 1953);
- lack of operating flexibility (Elliot, 1953); and
- low morale (Elliot, 1953; Strauss, 1955; Guest, 1957a).

Benefits claimed to accrue to the company from the respective changes included :

- improved productivity (Strauss, 1955; Guest, 1957b);
- improved quality (Strauss, 1955; Guest, 1957a and b);
- easier to trace errors (Guest, 1957 a and b);
- reduction in labour turnover (Guest, 1957a; Krugman, 1957);
- improved operating flexibility (Elliot, 1953; Guest, 1957a and b);
- reduction in idle time (Elliot, 1953);
- reduction in labour costs (Krugman, 1957);
- reduction in materials handling requirements (Guest, 1957b);
- fewer bottlenecks in production (Guest, 1957a); and
- reduced need for direct supervision (Guest, 1957b).

Operators also benefited from job enlargement :

- increased satisfaction (Strauss, 1955; Guest, 1957 a and b; Krugman, 1957);
- increased understanding of operations (Elliot, 1953; Guest, 1957a);
- more job variety (Elliot, 1953);
- less monotony (Guest, 1957a); and
- increased earnings (Strauss, 1955; Guest, 1957a).

With such a comprehensive list of tangible benefits, it is little wonder that management should have readily embraced the technique and there were probably numerous unreported applications. Those which have been mentioned here were widely discussed and

publicised in a diversity of journals including "Occupational Hazards" (1954), "American Mercury" (Wharton, 1954), and "Nation's Business" (Lagemann, 1954).

First Generation Theory : Job Enlargement Critics

The model presented in Figure 2.2 above did not pass without criticism. Three main links in the argument were immediately open to question :

1. does repetitive work necessarily create boredom?
2. does boredom necessarily have adverse effects on attitudes and output?
3. if 1 and 2 are true, does job enlargement provide an adequate solution?

The first point had already been examined by industrial psychologists in Britain whose work was replicated and expanded upon, P.C. Smith (1955) suggesting a number of personality characteristics which along with task characteristics could determine the individual's susceptibility to boredom. Due to the spread of individual differences, some workers could be expected to find repetitive work tolerable, if not positively satisfying (Smith and Lem, 1955; Brayfield and Crockett, 1955). In a study of 115 electronic instrument assembly operators, Turner and Miclette (1962) claimed (unconvincingly) to have shown that :

".... repetitiveness of a job is not an important source of dissatisfaction or low morale." (p.215).

The work of these operators was certainly not typical repetitive work; the operators considered that they were serving their country (the components were regarded as essential to national defense), although

repetitive the work was regarded as highly skilled, and operators did have some control over work pace and methods.

With regard to the relationship between employee attitudes and productivity, Brayfield and Crockett (1955), in an extensive review of relevant literature, concluded that :

".... there is little evidence that employee attitudes of the type usually measured in morale surveys bear any simple - or, for that matter, appreciable - relationship to performance on the job." (p.408)

Kennedy and O'Neill (1958) could find no difference in attitudes towards work and supervision between assembly operators on repetitive tasks and utility men doing similar but more varied work. But other utility men whose work had been upgraded and included responsibility for work methods and operator training did have more favourable attitudes. The original utility man's job illustrated, in comparison to the assembly operators, what would now be called "horizontal" job enlargement, i.e. more of the same type of task. The upgraded utility man's job had in contrast been "vertically" enlarged. Kennedy and O'Neill did not use these terms but were correct in concluding that the changes which produced the attitude differences were ".... along more fundamental dimensions" (p.375). This also concerns the third point listed above.

In another somewhat unconvincing study, conducted by Kilbridge (1960a), of over 200 assembly workers in a Chicago radio and television factory, the majority of workers appeared to prefer, or were indifferent to, smaller as compared to larger tasks, and conveyor pacing. Kilbridge argued that these workers did not want their jobs enlarged. There was, however, not much difference between the small and large tasks considered, the former including 7 "elements of work"

and the latter fourteen. The company had a high rate of labour turnover and Kilbridge included in his sample only those who had been with the company for over a year (in fact the average length of service was, for women, $4\frac{1}{2}$ years, and for men, 6 years). Rather than restrict his survey to this self-selected sample, he could perhaps have also examined why the substantial numbers leaving the company's employ were doing so. It is conceivable that those workers who left could not tolerate the boring tasks they had been requested to perform. In a confusing and brief account of a job rotation scheme which backfired (confidently described as a job enlargement scheme) Rosen (1963a) claimed that rotation does not necessarily increase variety and this is not necessarily its only consequence. What the workers in this instance seemed to want were more flexible working arrangements which the company's rotation plans did not provide.

These critics were on the whole unable to compete with the impressive results which the technique seemed to produce. What these reports did indicate, on the other hand, was the inadvisability of making simplistic generalisations such as "all workers find repetitive work boring", "dissatisfaction always reduces productivity" and "job enlargement is a generally applicable panacea".

With the breadth of perspective which Merton considered necessary, Georges Friedmann provides a more detailed and comprehensive overview of the developments discussed up to this point. In "Industrial Society" (Friedmann, 1955) he covers the scientific management movement in America and the growing rejection of its "technicist perspective". Friedmann also describes the application of scientific management in Europe (e.g. the ridiculous use of time

study by Renault at Billancourt where some workers found that the only way to maintain the established pace was by using their heads as well as their limbs to operate the machinery; pp.42 and 264-266).

Published originally in France in 1956 as "Le Travail en Miettes" (Work in Crumbs), "The Anatomy of Work" appeared in English in 1961 and Friedmann again displayed his acquaintance with the British and American work mentioned so far. Friedmann introduced several themes, which will be taken up in following sections, based also on the work of previous political theorists, notably Durkheim. The personality of the worker in repetitive work he claimed, finds no means of expression, and the work is, therefore, alienating. Friedmann also argued that over-specialised work affects mental health through the generation of psychosomatic complaints and neuroses in industrial workers. These were areas to be covered later, by Blauner and Kornhauser, in more detail. Friedmann was critical of solutions to these problems based on increased use of automation and extended leisure time. Automation, he argued, cannot take place at the speed predicted by its advocates; and those who find little opportunity for self-expression at work tend to spend their time in escapist activities rather than treating this as an alternative avenue of fulfilment. In a particularly uncompromising criticism of the leisure argument, which provokes an instant reappraisal of one's own leisure activities, Friedmann suggests that the combination of task fragmentation and increased leisure time will tend :

".... to arouse aggressive tendencies and outbursts of savage self-assertion through indulgence in all kinds of stimulants, in alcohol, in games of chance or luck, or in habits or bouts of "conspicuous consumption", brutal amusements like "stock cars" and mass-spectacles disguised as "sport" or "artistic" events, boxing, all-in wrestling, speed racing and crime and horror films." (Friedmann, 1961, p.104)

Unlike his contemporaries in this area, Friedmann claimed that job enlargement and rotation were inadequate measures in themselves to counter problems of repetitive work. He felt that work should be a learning experience :

".... providing a worker with an elementary knowledge of mathematics, the physical sciences, and drawing and technology, such as will enable him to understand what he and his fellows are doing - and so to control it."
(Friedmann, 1961, p.100)

From his review of contemporary work, Friedmann thus anticipated a number of directions which future research would take, and some of its conclusions. His own work thus provides a convenient link between this and the next section.

Second Generation Theory : A More Sophisticated Model

The increasingly cautious and critical approach developed in the 1960's produced a realisation of three main groups of factors; that repetitive work may have consequences for the worker more fundamental than boredom, that the relationships between workplace and worker characteristics, productivity and satisfaction are considerably more complex than had at first been supposed, and that job enlargement as a management technique could be justified on technical and economic advantages alone.

In his comparative study of work in four (American) industries, Blauner (1964) attempted to show how certain technologies produced alienation in the workforce. Blauner's definition of alienation comprised four ingredients : powerlessness, meaninglessness, social isolation and self-estrangement. The printing industry, operating mainly with craft work, is thus described as non-alienating, the worker having complete control of the process and close association

with the finished product. The textiles and automobile assembly industries, particularly the latter, are on the other hand described as highly alienating with extremely mechanised repetitive production processes. Technology, through alienation, Blauner argued, contributes to the creation of distinct social personalities: ideally, when work is non-alienating as in the printing industry, it tends to produce:

".... a strong sense of individualism and autonomy, and a solid acceptance of citizenship in the larger society." (Blauner, 1964, p.176)

Blauner was, of course, taking the American printing industry as it operated in the 1950's and 60's, and developments in the technology of printing since then have probably removed most of what Blauner saw as desirable in the industry. Blauner is so far in agreement with Friedmann in suggesting that working conditions have repercussions affecting not only working life but also the fabric of the worker's social life as a whole. Blauner's more contentious argument, however, is that alienation will eventually be eliminated by technological progress. In support of this argument he cites the example of the chemicals processing industry, which is highly automated, as another example of non-alienating working conditions. Friedmann would certainly not have agreed with this, and neither did Blumberg (1964) who argued that automation, if it is a solution at all, will not happen quickly enough, will not affect a significant number of jobs, and is thus no answer to current problems. The debate is still very much alive as to whether or not automated industries offer jobs with more desirable characteristics; this question is dealt with briefly below, pp.202-205.

Another reported effect of repetitive work concerned mental

health. In a survey of over 400 male shop-floor workers in thirteen Detroit car factories, Kornhauser (1965) found that on his index those performing skilled work were in better mental health than those performing routine machine-paced work. The worker on the repetitive task was no longer merely bored, he was alienated and his psychological well-being had become questionable. This was the type of problem for which job design in general had to provide some solution.

The theory presented in Figure 2.2 was clearly inadequate and as an example of the type of model which superseded it, Figure 2.3 has been derived from Katzell, Barrett and Parker (1961). This model is indicative of the type of approach being adopted, different researchers placing different emphases on the implied variables. At this level of generality, the model is characteristic of what is here described as second generation theory.

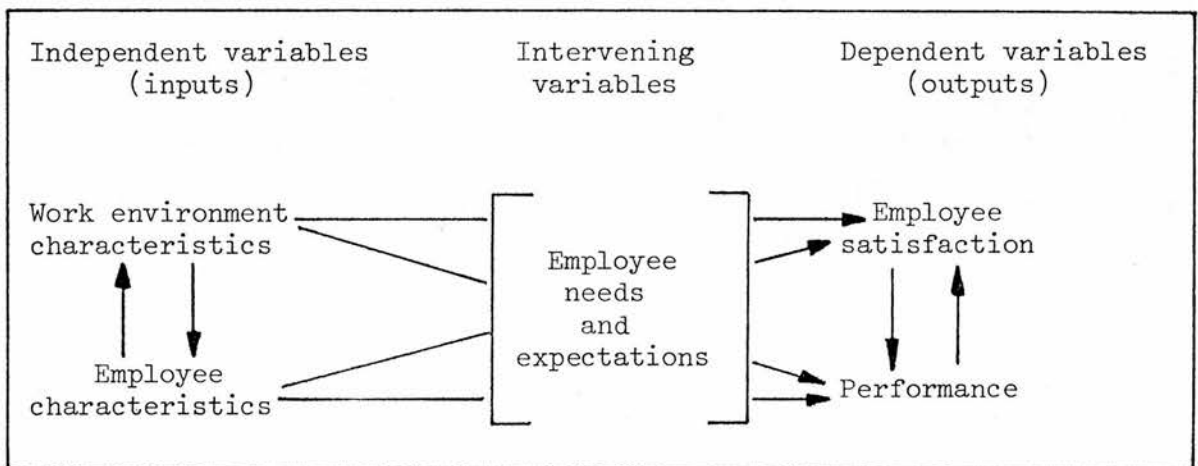


Figure 2.3 : Model of the work situation; second generation theory (based on Katzell, Barrett and Parker, 1961).

In presenting their argument, these authors criticised the over simple two-variable research designs of the past; the arrows in Figure 2.3 indicate expected interrelationships which only a

multivariate approach could hope to illuminate. The work of Turner and Lawrence (1965) illustrates the applicability of this model fairly well.

Turner and Lawrence set out to examine the relationship between job characteristics and worker behaviour. A method of rating jobs was developed incorporating several main dimensions - variety, autonomy, interaction opportunities (on and off the job), responsibility, learning time; and subsidiary dimensions - required interaction, task identity, cycle time and working conditions. Having devised rating scales for each of these dimensions, the resultant measure was the Requisite Task Attribute (RTA) index, and Turner and Lawrence began to examine correlations between RTA ratings, and job satisfaction and absenteeism, for 470 workers in 47 jobs in 11 different industries. The predicted negative correlation between RTA rating and absenteeism was found, i.e. workers on jobs with high ratings had significantly lower absenteeism rates than those on jobs with low ratings. Their results are so far consistent with those of Walker and Guest (1952) whose "mass production" scores are similar to the RTA index. No correlation was found, however, between RTA ratings and job satisfaction until the study's population was divided into a "Town" or rural group and a "City" or urban group. The former showed more satisfaction with highly rated jobs (which Turner and Lawrence called "complex" work) but City workers seemed to prefer jobs with low RTA ratings ("simple" work). Not only did job characteristics affect worker behaviour, subcultural factors (or "social system variables") also appeared to have a significant bearing on employees' expectations and attitudes towards work. These results are clearly

consistent with the second generation theory, but Turner and Lawrence realised that the gross distinction which they had made in order to explain their data had concealed a host of underlying variables and that the detailed relationships, could they be worked out, would not be simple ones. Insofar as the distinction proved useful, however, the authors turn to Durkheim's theory of anomie to suggest that urban and city environments contribute to the phenomenon which they had discovered. (In fact, the importance of subcultural influences on attitudes to work had been suggested by Worthy (1950), and Katzell, Barrett and Parker (1961).)

As far as job enlargement was concerned, any generalisation with respect to its applicability and results became subject to obvious qualifications. Others continue to assert that the application of job enlargement should be carefully selective (cf. Wild, 1969, 1970, 1973, and Scott, 1973), in view of the fact that many workers reject such attempts to improve their lot, and are contented with what appears to most (middle-class) researchers to be dismal boring work. Before leaving Turner and Lawrence, it is noteworthy that the list of task attributes which they found to be significant included far more than variety and cycle time.

In practice, the technique of job enlargement had other limitations. Stewart (1967) for example gives the following:

- there is an upper limit of job complexity, determined by cycle times, beyond which a job cannot be enlarged;
- job enlargement often requires more space and duplication of expensive equipment;
- job enlargement is often restricted by process limitations;

- it generally requires extended (costly) training;
- unplanned absence creates replacement problems.

These, of course, reflect the earlier arguments for job simplification. The emphasis on behavioural effects of job enlargement, therefore, decreased in favour of a more careful appraisal of economic considerations (cf. Schoderbek and Reif, 1969). Tuggle, for example, states that job enlargement :

"... provides a way of effectively reducing assembly labour costs with a minimum of worker resistance. It can improve quality by emphasising craftsmanship and creating worker identification with the product. At the same time, it provides simple ways of tracing rejects to workers who need additional training. Finally, it affords greater scheduling flexibility than was ever possible on the assembly line for variations in demand up to 20 per cent." (Tuggle, 1969, pp. 28-29)

Job enlargement can thus be used to subject the worker to increased managerial control as well as to grant more freedom at work.

By this point in time the technique of "job enrichment" (dealt with below) had been developed and publicised, and from around 1968 there has tended to be some confusion over terminology. Lawler (1969) distinguishes between two forms of job enlargement, horizontal and vertical. (See also Gomersall and Myers, 1966, p.63.) The former we have been considering up to now, the latter is more commonly referred to as job enrichment. The distinction is as follows :

"The horizontal dimension refers to the number and variety of the operations that an individual performs on the job. The vertical dimension refers to the degree to which the job holder controls the planning and execution of his job and participates in the setting of organisation policies." (Lawler, 1969; p.164 in Vroom and Deci, 1970.)

Studies from this period onwards using simply the term "job enlargement" require examination to determine which variety is being referred to. It is Lawler's conclusion that both are necessary to elicit intrinsic worker motivation, but this is anticipating later developments.

Job enlargement in practice during the 1960's will first be examined.

Second Generation Theory : Further Applications of Job Enlargement

Job enlargement undertakings in the nineteen sixties and early seventies have not been qualitatively different from their precursors. Most involved the replacement of assembly line production methods with individual assembly stations (e.g. Kilbridge, 1960; Biggane and Stewart, 1963; Conant and Kilbridge, 1965; Pauling, 1968; Thornely and Valantine, 1968; Philips Report, 1969) or in one case with small assembly groups separated by buffer stocks (Van Beek, 1964). Cotgrove, Dunham and Vamplew (1971 : "The Nylon Spinners, a case study in productivity bargaining and job enlargement") report a project in the traditional Richardson and Walker (1948) style, although the interpretation of their results is along more careful lines. These projects are on the whole better observed and documented than previous studies, but more emphasis has been placed on economic than behavioural results. Kilbridge (1960b) for example cites one case study which he claims was justified by "tangible cost savings" alone (produced mainly through reduction in idle time). The design of these "experiments" continued to attract criticism from those who argued that the lack of experimental controls left the results open to alternative explanations. (cf. Schoderbek and Reif, 1969, p.15; and Bishop and Hill, 1971, p.175.) Bishop and Hill, in fact, argue that, in terms of effects on output and productivity, a change is as good as an enlargement. They used as subjects 48 clients of an Employment Training Center at Southern Illinois University (a sheltered workshop for the rehabilitation of the mentally and physically handicapped). The

workers either changed during the experiment from sorting nuts to sorting bolts (or vice versa), or had their job enlarged to include assembling nuts and bolts and packing them. The changes produced similar results.

Some confusion over the nature of job enlargement effects had occurred previously. Kilbridge (1960b) gives the following definition :

"Job enlargement is the expansion of job content to include a wider variety of tasks and to increase the worker's freedom of pace, responsibility for checking quality and discretion for method." (Re-stated in Conant and Kilbridge, 1965.)

Kilbridge was asserting that there should be more to job enlargement than mere task recombination, claiming that :

"If connecting black wires is boresome, why should connecting black and yellow wires be less so?" (Kilbridge, 1960b, p.358.)

This is the traditional criticism of horizontal job enlargement and anticipates the development of job enrichment, the technique described in the next section. Job enlargement lacked a systematic theory and, more important, a methodology. From a postal survey (with a 75 per cent response rate) of 276 companies selected at random from the 1965 Fortune Directory of the 500 largest American industrial concerns, Schoderbek and Reif found that over 80 per cent of their sample had never used job enlargement, and most of these had never considered it. As part explanation for this, Schoderbek and Reif said that they were :

".... unaware of any available guidelines at this time which state how to go about enlarging jobs, determining which jobs to enlarge, what problems to expect and how to deal with them." (1969, p.34)

But an attempt had been made to provide a systematic solution to these questions, by Frederick Herzberg whose technique of job

enrichment had been published in 1968, (although the theory behind it had been first published in 1959). In summary, before turning to Herzberg's work, four trends have been identified in the job enlargement literature and these are briefly :

1. ambiguity with respect to what job enlargement (vertical or horizontal) actually involves;
2. increased awareness of the complexity of relationships between attitudes towards work and behaviour in general;
3. realisation of the importance of individual and sub-cultural differences in attitudes towards work and receptivity to job enlargement;
4. increased emphasis on the technical and economic advantages of job enlargement and reduced emphasis on behavioural effects.

Third Generation Theory : Herzberg's Job Enrichment

Within the research tradition examined up to this point, no author, with the possible exception of Blauner, had attempted to construct a "general theory" of the psychological relationship between man and work - in the sense that Keynes had provided economists with a "general theory" (of employment, interest and money) in 1936. Blauner's approach was a sociological one, dealing with the relationships between organisations, technology, and sub-cultural groupings; his direct concern was not with the individual's relationship to his work. The work of Frederick Herzberg in this latter direction is now widely known, and constitutes the focus of attention of this section. The popularity of his work is excuse for avoiding a greatly detailed description of it here.

Herzberg is now University Distinguished Professor at the College

of Business, University of Utah, and while his writings have attracted much criticism, his effort in constructing a theoretical system of the kind referred to above suffers inadequate appreciation. He has attempted to relate what he takes to be human nature to the experience of satisfaction at work, and to produce a comparatively simple technique for rectifying the deficiencies in job content, creating, in a sense, a "co-incident of wants" between the nature of the worker and the requirements of the job.

Herzberg's earliest work was carried out in the mid 1950's while he was Research Director at the Psychological Service of Pittsburg. An extensive review of the literature on job satisfaction had revealed some anomalies with respect to the factors which appeared to be associated with job satisfaction, and those associated with dissatisfaction (Herzberg, Mausner, Peterson and Capwell, 1957). In order to explore these anomalies further, 203 Pittsburg engineers and accountants were interviewed and asked to relate events which had made them feel good about their work, and events which had made them feel bad about it (Herzberg, Mausner and Snyderman, 1959). Content analysis of the interview protocols revealed that the factors given as producing job satisfaction were different from the factors producing dissatisfaction. The factors producing job satisfaction are variously referred to as "satisfiers", "motivators" or "content factors", and these include - "achievement", "recognition", "responsibility", "advancement", "growth", and the "work itself". Factors producing job dissatisfaction are termed "dissatisfiers", "maintenance factors", "hygiene factors" or "context factors" and these include - salary, company policy and administration, supervision,

status, security, and working conditions. The characteristics of work conducive to job satisfaction are, therefore, qualitatively different from those which produce job dissatisfaction. If satisfied workers are motivated to higher productivity, the implication for management policy is that this can be achieved with a minimum of expenditure; increasing wages or improving working conditions will probably not motivate employees to better performance whereas providing responsibility and opportunities for growth in competence probably will. Continuing the multiple terminology, this is known as the "two factor" or "motivator - hygiene" theory of job satisfaction.

In his third book, *Work and the Nature of Man* (1966), Herzberg brings together his previous work, placing it within a more comprehensive framework. This book, together with a paper published in 1968, sets out the essentials of Herzberg's "general theory", what is referred to here as third generation theory. The theory is ambitious, but its breadth of scope gives it both advantages and disadvantages. As his starting point, Herzberg describes the "basic needs of man" and the primacy of desire for psychological growth. One fundamental premise is that a society's dominant institution, in our case industry, formulates a concept of the nature of man which is in accordance with its own perceived requirements for survival. Problems will arise where this formulation is at odds with the true nature of man, and Herzberg argues that our dominant institution has indeed got it wrong. The two factor theory of job satisfaction illustrates man's striving (through his work) to satisfy basic needs - through the hygiene factors - and to satisfy the desire for psychological growth - through the motivator factors.

Herzberg makes the further claim here that those who seek the motivators are mentally healthy, whereas "hygiene seekers" are neurotic, having erroneously adopted the institutional concept of their nature. In order to rectify this state of affairs, Herzberg produced a ten step "check list" for implementing job enrichment (Herzberg, 1968), which shows how the motivator factors can be "built into" individual jobs.

While this "theoretical system" is consistent within itself, any part of it may be modified without greatly damaging the integrity of the other parts. Proof that job satisfaction and dissatisfaction are affected by the same factors would not on its own prompt a revision of the view of human nature proposed; the job enrichment technique could, with supporting research results from successful applications, be argued to have a validity independent of the two factor theory. It is, however, worth while looking at the three facets of the theory in a little more detail because while it does not particularly matter what their precise content is, it is important that Herzberg found it necessary to bring these notions together at all. His concept of what such a theory should be, and what it should take account of is more important than whether or not his construction is correct.

Human Nature :

The relationship between man and work is mediated by human nature, and man, argues Herzberg, has two sets of basic needs in the form of -

- (a) a constant need for cortical stimulation, and
- (b) the need for psychological growth.

The former is a fairly well accepted phenomenon, supported by the results of multifarious experiments concerning sensory deprivation where lack of stimulation, or sensory input, can seriously disturb those subjected to the treatment, producing hallucinations and other undesirable side-effects. Cortical stimulation is thus essential to mental health and Herzberg argues that psychological growth has similar status; it possesses six characteristics, three in a cognitive category and three in a motivational category:

Cognitive characteristics -

1. knowing more
2. acquiring relationships in knowledge
3. creativity

Motivational characteristics -

4. effectiveness in ambiguity
5. individuation
6. real growth (perception of reality, self-perception).

Herzberg describes these characteristics at some length in "Work and the Nature of Man", and full examination here would also require a discussion of competing theories which is outwith the scope of this review. Suffice it to say that the concept is value-laden as are other similar formulations. (See, for example, the summaries of the theories of Herzberg, Jahoda and Kornhauser in Warr and Wall, 1975, Chapter 1.) On the other hand, this is not a reason for avoiding the issue, for Herzberg thought it necessary to attempt to establish a systematic link between human nature, the perception of work, and mental health.

Job Satisfaction:

This aspect of Herzberg's work has provoked much criticism, argument and research, much of which is examined below. The first prize now goes to a unidimensional theory of job satisfaction as opposed to Herzberg's two factor theory, but the adjustment has been one of emphasis rather than direction. The motivator factors appear to have greater overall effect on satisfaction and dissatisfaction than do the hygiene factors; the motivators are simply more powerful all round. In dividing the two sets of job factors identified in the Pittsburg study into satisfiers and dissatisfiers, the former came to be called "motivators" because :

".... other findings of the study suggest that they are effective in motivating the individual to superior performance and effort." (Herzberg, 1966, p.74)

Herzberg tends to use the terms "job satisfaction" and "motivation" synonymously, but the implication is that the performance of the motivation seeker who has found what he is looking for will be better than that of one who has not, or indeed of a mere hygiene seeker. The hypothesised relationship between job satisfaction and performance had by 1966 suffered some rough handling as indicated above, but Herzberg's formulation casts this hypothesis in a fresh light by suggesting that only true job satisfaction - as opposed to lack of job dissatisfaction - produces improved performance. Once again, Herzberg is attempting to establish a link between human nature, the perception of work and satisfaction with work, and worker behaviour.

Job Enrichment:

It is Herzberg's view that if work does not produce satisfaction,

but rather disrupts mental health, and is not in accord with man's essential nature, then work must be changed; the approach to this is through restructuring the individual job.

Towards the end of "Work and the Nature of Man", Herzberg makes the following comment:

"What recommendations can be made to industry in order to carry out the ideas propounded in this book? I am tempted to reply that if I had the answers, I would program them and make a living in a much easier way than by writing books." (Herzberg, 1966, p.171.)

In answer to this plea, his well known article "One More Time : How do you Motivate Employees?" appeared in the Harvard Business Review in January 1968. In it he listed seven "principles of vertical job loading" and presented a ten-point check-list, or job enrichment programme, to implement them. The vertical job loading principles, which are related to the motivator factors, are:

- A. Removing some controls while retaining accountability.
- B. Increasing the accountability of individuals for own work.
- C. Giving a person a complete natural unit of work (module, division, area and so on).
- D. Granting additional authority to an employee in his activity; job freedom.
- E. Making periodic reports directly available to the worker himself rather than to the supervisor.
- F. Introducing new and more difficult tasks not previously handled.
- G. Assigning individuals specific or specialised tasks, enabling them to become experts.

(Herzberg, 1968: in Davis and Taylor, 1972, at p.119)

The ten-point check-list for implementation is, briefly, as follows :

1. Select for enrichment those jobs in which -
 - "(a) the investment in industrial engineering does not make changes too costly,
 - (b) attitudes are poor,
 - (c) hygiene is becoming very costly,
 - (d) motivation will make a difference in performance."

(In Davis and Taylor, 1972, p.123.)
2. Examine these jobs with the conviction that job content can be changed.
3. "Brainstorm" a list of possible job enrichment changes (this is also sometimes called "greenlighting").
4. Screen the list for hygiene suggestions, retaining those concerned with motivators.
5. Screen the list for vague generalities, selecting specific suggestions concerned with motivators.
6. Screen the list for horizontal loading factors.
7. Avoid employee participation in determining the changes to be made.
8. Set up a controlled experiment to examine the job enrichment effects.
9. Initial results will be poor, until employees become accustomed to their new jobs.
10. Initial reaction from first-line supervisors will probably be anxiety and hostility.

At the end of this article, Herzberg asserts that :

"If you have someone on a job, use him. If you can't use him on the job, get rid of him, either via automation or by selecting someone with lesser ability. If you can't use him and you can't get rid of him, you will have a motivation problem." (in Davis and Taylor, 1972, p.125)

The technique has obvious economic and behavioural attractions

for management; it appears to be comparatively straightforward and logical, and capable of producing tangible results, and there is no need to directly involve the employees in the process. (Herzberg apparently told David Jenkins (1974, p.169) that he was not in favour of employee participation in the job enrichment process because - " There is a danger you will participate beyond your level of competence.") From the first point on the check-list, however, Herzberg appears to be advocating job enrichment as a last resort, useful only in situations where things are so bad that any change which could be described as an improvement would produce beneficial results. The recommendation that employees do not participate is contentious, others having claimed that employee involvement in the change process is desirable; see, for example, Coch and French, 1948. Herzberg's recommendation has not always been adopted in practice, various companies having involved their employees in differing degrees in the job enrichment process.

In 1974, Herzberg provided slightly more detailed advice on what he believes constitutes the "ingredients of a good job".

These are :

Ingredient:	Explanation:
1. Direct Feedback	<p>"(a) that the results of a person's performance be given directly to him rather than through any supervisor, performance review, or bureaucratic innuendo, and</p> <p>(b) that this feedback be nonevaluative and timely."</p>

Ingredient:	Explanation:
2. Client Relationship	".... that the individual has a customer or client to serve, whether external to the organisation or inside it."
3. New Learning	".... the opportunity for individuals to feel that they are growing psychologically. All jobs ought to always provide an opportunity for the worker to learn something purposeful and meaningful."
4. Scheduling	".... the opportunity to schedule one's own work."
5. Unique Expertise	".... need for some personal uniqueness at work - for providing aspects of jobs that the worker can consider as 'doing his own thing!'"
6. Control over Resources	".... responsibility for costs."
7. Direct Communications Authority	self explanatory: ".... enhances the growth potential of a job by providing the worker with new avenues of information."
8. Personal Accountability	".... remove the crutch of inspection and instead directly identify the performance of the work with the individual."

(From Herzberg, 1974, pp.72 to 74)

Apart from descriptions of applications of job enrichment in practice, Herzberg has never described job enrichment in any greater detail. Implementation is situational and is, therefore, flexible; an obvious advantage in practical terms but one which as will be argued below points to the inherent weakness of the technique as a device for organisational analysis and change. This third facet completes Herzberg's "general theory", backing up his theoretical

arguments with concrete guidelines for change and improvement.

Third Generation Theory : Support and Development

Herzberg's ideas about human nature have not attracted a great deal of attention, whereas his theory of job enrichment has attracted a number of enthusiastic adherents. The two factor theory, on the other hand, has been heavily attacked but its superficial attraction created some initial support. Rosen (1963b) for example showed how "intrinsic job demands" were more important to research and development workers than salary appeared to be (a very attractive finding indeed). The reasons why scientists and engineers either stayed in or left their jobs also appeared to differ along the lines predicted by the two factor theory (Friedlander and Walton, 1964); i.e. their reasons for resigning were not simply the opposites of their reasons for remaining. Personality differences in employees at all levels in Texas Instruments Inc. (a company which applied job enrichment in several areas, with much reported success) were shown to differentiate between motivation seekers and hygiene seekers (Myers, 1964). Saleh and Hyde (1969) asked 1200 employees to rank in order of personal importance twelve work factors, six of which were "intrinsic" and six "extrinsic". As the two factor theory would predict, the "internally oriented group", indicated a higher degree of job satisfaction than the "externally oriented group." (The dominant orientation of men in this sample was intrinsic, whereas that of woman was extrinsic.) Ford and Borgatta (1970) identified clusters of factors from a job satisfaction survey which indicated that factors associated with satisfaction were essentially those which Herzberg had called "motivators". And Herzberg's own

ambiguously titled paper "The motivation to work among Finnish supervisors" was an attempt to prove the cross-cultural validity of the theory. (Herzberg, 1965.) Rather than being subject to strict definition, the motivator factors can be expressed in a variety of ways. Dickson (1971) for example suggests that the key features of job content which influence an individual's behaviour at work are :

1. predictability (related to discretion),
2. variety (of tasks),
3. meaning (degree of fragmentation).

The Manager of the Management Training Division of Chase Manhattan Bank, New York, claims that job enrichment comprises five "structural concepts", i.e. job content should incorporate:

1. natural units of work,
2. "client identification",
3. vertical and horizontal job loading,
4. feedback systems,
5. task advancement. (Greenblatt, 1973, pp. 32-33.)

The extent to which these re-statements of the original theory assist the practitioner or develop the theory is debatable.

Herzberg's work at the Psychological Service of Pittsburg was taken up by R. Hackman (who also took up Herzberg's job as Research Director there). Hackman's continued support for the two factor theory is based on a re-examination of Herzberg's original data and further research of his own (mainly using the "Hackman Job Satisfaction Schedule"). His position is similar to that of Herzberg's, and he states that :

"Job conditions producing motivationally significant feelings reinforce adaptive work behaviour and attitudes

and serve the useful function of maintaining or augmenting work effectiveness. Job conditions generating emotional tension produce nonadaptive work behaviour and attitudes and serve to reduce work effectiveness." (Hackman, 1969, p.127.)

Hygiene seekers are re-named "responders" and motivation seekers are re-named "stimulation seekers". (Hackman, 1969, p.29.)

Hackman's overt behaviourist approach thus reduces the practice of job redesign to a manipulatory technique in which the task of the manager is to :

".... try to adapt the available reinforcing agents to the range of individual differences among the men he has working for him." (Hackman, 1969, p.155.)

In restating the theory in this manner, only a trace of Herzberg's essentially humanistic theory is retained, and in so doing Hackman has placed himself completely outwith the ethos of the research trends with which we are dealing here.

Robert Ford, now well known for his direction of the implementation of job enrichment in American Telephone and Telegraph has also tended to deviate somewhat from the master's teaching, and in a more recent paper describes how work can be organised beyond the enrichment of individual jobs by "nesting". (Ford, 1973.) He also calls this "work organisation", and this is almost the sense in which Wild (1975) uses that phrase. With reference to an order processing department, Ford describes the establishment of "minigroups" each of which can handle the complete processing of an order from start to finish, in place of groups which were functionally divided, processing orders by passing them from group to group. Ford is thus advocating the use of quasi-autonomous groups (of which more will be said below) and Herzberg is clearly against this, critical of the possibility of the "tyranny of the group" being used against the

individual (Herzberg, 1974). On the precise practical details of nesting, Ford is somewhat obscure, and in one particularly abstruse statement suggests that jobs should be loaded horizontally - "...until the base of the job is right", but gives no indication of how to assess whether this stage has been reached.

Three articles which appeared in 1973 criticise not the application of job enrichment but its indiscriminate application. Sirota and Wolfson (1973) for example argue that the success of job enrichment as a managerial technique is dependent upon correct diagnosis of the presenting problem and that a "diagnostic approach" should be adopted in order to discover "exactly what is bothering employees". This is now called the "contingency" approach to job enrichment, the central hypothesis of which is summarised by Morse, who states that :

"Only when all three inputs - a job design, individual predispositions and technological variables - are contingent on and fit each other systematically is there likely to be high employee motivation and high task performance."
(Morse, 1973, p.69.)

As Monczka and Reif (1973) point out, this is in fact a "systems approach to job design" (p.11), but this should in no way be confused with the "socio-technical systems" approach developed in Britain. Much of the contingency approach is at least implicit in Herzberg's own writings, e.g. the identification of jobs which are suitable for enrichment taking into account workers' attitudes, technological constraints, and supervisory and management reaction to proposed changes. (See Herzberg, 1968.)

After much initial enthusiasm, therefore, even job enrichment exponents are now careful to point out that the technique is not generally applicable but, and this is probably true of all job redesign approaches, that success is situational :

".... the concept works best in situations where the workers seek fulfilment in their work and are eager to move to enriched jobs, technological considerations are favorable, and management is committed and capable of developing and implementing job enrichment projects." (Monczka and Reif, 1973, p.12.)

In contrast to those who would limit the application of job enrichment there are on the other hand those who argue that it is necessitated by current social and economic conditions. Herzberg's case for job enrichment rests on the disparity between human needs and the extent to which these are expressed and unfulfilled in work, but other commentators have attempted to justify its employment with reference to the implications of various trends in (American) society as a whole. Foulkes (1969), for example, claims that the popularity of job enrichment has been due to five factors :

1. an increasing volume of behavioural science knowledge,
2. increased domestic and foreign competition,
3. growth of trade unions and management's dislike of restrictive practices,
4. evidence of labour force discontent,
5. possible union interest in the technique.

Three further reasons for the necessity of job enrichment are given by Maher and Piersol (1971) who mention :

1. government and "organised labor" involvement and concern,
2. predicted shortages of professional managerial personnel,
3. the attitudes and values of American youth.

Skinner (1971) in giving us his reasons for reappraising current production methods, suggests a further reason :

1. technological change (in production and information handling), as well as those covered so far :
2. changing (American) beliefs and expectations,

3. growing foreign competition.

From the Australian viewpoint, Elliott (1972) suggests that three factors will further the application of job enrichment :

1. labour shortages created by a decrease in immigration,
2. increases in labour demands,
3. the consequent challenge to managerial authority.

The rejection of monotonous work by British youth, claim Mandle and Lawless (1971) has contributed to the increase in sales of "soft" drugs in factories and offices; and Sheppard and Herrick (1972) provide extensive data on the extent of alienation amongst young American workers.

There is, therefore, some agreement on a number of major social trends taking place, at least in American society. But is job enrichment really going to improve the individual company's market position, assuage foreign competition, restrict the spread of unionisation, mollify a discontented workforce and alleviate manpower shortages? If the contingency approach advocates are correct in their views on the use of job enrichment then the technique is on the whole unlikely to have a tremendous impact on the social trends which are said to necessitate it.

Before turning to the criticism and disputes which Herzberg's theories have generated, it is appropriate at this point briefly to summarise and review Herzberg's contribution to this field. There are at least three points of note.

1. His theories have stimulated vast quantities of research and debate concerning motivation and job design.
2. Management in America, and to some extent in Europe, has become more aware through his writings of the problems which

give rise to the development of techniques such as job enrichment.

3. Whatever status it commands today it is significant that Herzberg found it necessary in the formulation of his theory of job design:

- (a) to incorporate a theory of human nature,
- (b) to show how man's basic needs manifest themselves in the work situation, and
- (c) to devise a practical technique by which job content could be improved to attempt to fulfil human needs expressed at work.

Herzberg has made no attempt to develop his ideas as they have been presented above, but has been more concerned with publicising them. His more recent articles (Herzberg, 1970, 1971, 1974) essentially cover no new ground and merely restate his previously published work. David Jenkins (1974) is particularly harsh on Herzberg in this respect, stating that :

".... he has concentrated primarily on his appearances before management groups - a kind of globe-trotting missionary, preaching the motivation-hygiene gospel with great wit and dynamism. In these appearances he tends to take a rather dogmatic view, implying that research carried out since his own has been on the whole quite unnecessary." (Jenkins, 1974, p.169.)

Subsequent research does not seem to have materially affected the application of job enrichment, especially in America, and for those employed as consultants in this lucrative field, as indeed Herzberg himself is, self-criticism may not be in their best interests. This may also account for the "overjustification" of job enrichment by Foulkes, Maher and Piersol, et al.

Keats, we are told, was overjoyed to discover ".... that one of his poems had become a popular 'folk-song', whose author's name had been

forgotten", and that this "... made him feel that he had become so much a part of the country that only his work remained."* Herzberg may now claim to hold an analogous position in the American "psychology of work" tradition in view of the large number of reported job enrichment case studies, and articles and books on job enrichment "implementation strategies" in which no reference to his name or to his writings can be found at all.

Third Generation Theory : Criticism and Refutation

The attack on Herzberg's theories has been made on two main fronts. First, there is the question of whether job satisfaction is a one-dimensional or a two-dimensional phenomenon, and second there is the question of the universality of appearance of "higher order needs" in man.

1. A one - or a two - dimensional theory?

It is now generally accepted (although perhaps not by Herzberg) that the results of the Pittsburg study and subsequent similar research are an artifact of the research methodology used. Vroom (1964) suggested that the interview procedure adopted could have evoked defensive and projective responses which in turn produced an apparent divergence between the factors which produced, respectively, job satisfaction and dissatisfaction :

"... obtained differences between stated sources of satisfaction and dissatisfaction stem from defensive processes within the individual respondent. Persons may be more likely to attribute the causes of satisfaction to their own achievements and accomplishments on the job. On the other hand, they may be more likely to attribute their dissatisfaction not to personal inadequacies or deficiencies, but to factors in the work environment, i.e. obstacles presented by company policies or supervision."
(Vroom, 1964, p.129.)

* Robin Skelton, *The Poet's Calling*, Heinemann, 1975, p.155.)

Bobbit and Behling (1972) requested some respondents to complete a critical incident type questionnaire in the belief that it was part of an organisational review, whereas others completed it believing that it was part of a university research project and individual replies would not be reported. The predicted defensive responses from those who were under the impression that their superiors would see their questionnaires did not take place. The replies of both groups were similar. Despite this attempt to disprove Vroom's hypothesis, the weight of evidence points to the conclusion that Herzberg's two factor theory of job satisfaction is method bound, different methodologies producing different results. King (1970) claims that lack of clarity in Herzberg's initial exposition has led to at least five different interpretations of it being used by others. None of these, however, fulfils the principle of "multiple operationalism" which states that :

".... a hypothesis is validated only if it is supported by two or more different methods of testing, where each method contains specific idiosyncratic weaknesses but where the entire collection of methods permits the elimination of all alternative hypotheses." (King, 1970, p.29.)

Studies which have produced results confirming the two factor theory have generally used the same or similar methodology as Herzberg, and those which have produced disconfirming results have generally used different methodologies. A review by Kaplan, Tausky and Bolaria (1969) of 39 research reports concerning the two factor theory produced the following result :

	Confirming results	Disconfirming results	
Same methodology as Herzberg	17	3	20
Different methodology from Herzberg	4	15	19
	21	18	39

Job satisfaction is thus now generally accepted to be a uni-dimensional concept, with Herzberg's satisfiers and dissatisfiers contributing to both job satisfaction and dissatisfaction with differential effects. Dunnette, Campbell and Hakel (1967) state that :

".... certain job dimensions - notably Achievement, Recognition and Responsibility - seem uniformly to be more important for both satisfying and dissatisfying job events and that certain job dimensions - notably Salary, Working Conditions, Company Policies and Practices, and Security - are relatively less important."
(Dunnette, Campbell and Hakel, 1967, p. 169.)

The motivator factors appear to be more potent in their effect on job satisfaction and job dissatisfaction than are the hygiene factors, and the two factor theory is thereby invalidated. This conclusion receives widespread support, e.g. from Ewen, Smith, Hulin and Locke, 1966; Graen, 1966; Kaplan, Tausky and Bolaria, 1969; Locke, 1973; and Spillane, 1973. Herzberg attempted to answer his critics on this point in "Work and the Nature of Man" stating :

"Employees who wish to make themselves look good are much more prone to say that they are unhappy because they do not have responsibility, are not getting ahead, have uninteresting work, see no possibility for growth and do not receive recognition than to say that their supervisor is unfriendly, the administration is poor, the working conditions are bad, their fellow workers are unsociable, etc." (Herzberg, 1966, p.130.)

This is possibly the type of answer which the researchers would have got had they asked their respondents to state whether they were "unhappy" about their work and, if so, why. This was not one of the questions used in the interviews, the technique involved asking the respondent to relate a specific time bounded sequence of events which had produced either good or bad feelings about the work. Herzberg's retort simply reinforces the method-bound characteristic of this type of data.

2. Is the pursuit of "higher order needs" universal?

Lupton (1971) describes Herzberg as belonging to that group which he calls the "psychological universalists" (which also includes McGregor, Blake, Likert and Argyris), whose approach relies on the assumption that the theories which they have evolved apply equally to all individuals, regardless of the situation in which they are applied. The division of job content factors into motivators and hygiene factors is closely related to the higher and lower order need dichotomy in Abraham Maslow's "need hierarchy" theory. (Maslow, 1943.) Herzberg's argument, with which Maslow is in general agreement, is that those who are concerned solely with the satisfaction of their lower order needs - hygiene seekers - are neurotic, and that the mentally healthy individual - the motivation seeker - is characterised by the desire to gratify higher order needs, particularly that of self-actualisation. (Herzberg, 1966, pp.80-81.) A number of researchers have taken issue with this point.

Centers and Bugental (1966) found job level to be a crucial variable in explaining differential orientations towards work in a sample of 692 "employed adults" in the greater Los Angeles area. Higher occupational levels (i.e. professional and managerial) tended to value intrinsic job components, lower occupational levels (i.e. semi-skilled or unskilled) valued extrinsic job components more. Application of the two factor theory is similarly limited, argue Blood and Hulin (1967), by the mediating effects of individual differences and subcultural influences on a worker's response to a job. (See also Hulin and Blood, 1968.) They suggest that extent of "integration with middle class norms" is a fairly reliable predictor of workers' response. This construct is conceived as a

continuum the extremes of which are integration with and alienation from middle class norms :

"At the integrated end of the construct are found workers who have personal involvement with their jobs and aspirations within their occupations. Their goals are the type of upward mobility, social climbing goals generally associated with the American middle class. At the opposite pole of the construct, workers can be described as involved in their jobs only instrumentally; that is, the job is only a provider of means for promoting extraoccupational goals. The concern of these workers is not for increased responsibility, higher status, or more autonomy. They want money, and they want it in return for a minimal amount of personal involvement." (Blood and Hulin, 1967, pp.284-285.)

Sub-cultural variances in the expression of desires for higher order need gratification indicate that for "alienated" workers, the most desirable jobs are those which require a minimum of personal involvement and a maximum financial return. This finding is in accordance with that of Turner and Lawrence (1965), discussed above, and of Goldthorpe et al (1968) in Britain. Hulin later argued (1971) that the 1967 approach had been unnecessarily indirect in attempting to identify "community variables" which would assist in the prediction of workers' attitudes to work. A simpler and more direct approach, he claimed would be to examine "higher order need strength" differences between individuals. The two factor theory is inaccurate in the assumption that no such differences exist, and Hulin is critical of the practice of "ethnomorphising" - imputing one's own values to another sub-cultural group.

The above considerations raise the problem of direction of causality; does incumbency of an alienating job generate alienation, or do alienated workers select such jobs in the first place? Goldthorpe et al (1968) state that their sample of car workers in Luton consciously selected and remained in their generally monotonous and tiring work solely for the extrinsic economic rewards

which it provided. Saleh and Hyde (1969) and Kaplan, Tausky and Bolaria (1969) argue, with Hulin and Blood, that self-actualisation is a motive acquired through socialisation. This would imply a "cycle of alienation" in which one generation transmits its attitudes and expectations concerning work to the next, perpetuating the social conditions and types of work which generate that alienation. The phenomenon is thus an interactive one and the problem of direction of causality is of little consequence. The concern with description and analysis appears to have precluded any consideration of the desirability of this state of affairs, or with how it might be improved or changed, and Blood and Hulin recommend that no attempt be made to enrich the jobs of workers whom they describe as alienated because such attempts will be rejected. This recommendation is based on implicit assumptions for which they produce no evidence. (See Shepard (1974) whose criticism of such a generalisation is briefly described below.)

The diverse manifestations of human nature makes it an extremely difficult concept to define, and it is not surprising that the Herzbergian archetype is not to be found throughout American society. The expression of so-called higher order needs is far from universal, but this in itself does not deny their potential existence. (Maslow would argue that they have become "blocked" through lack of opportunity to find satisfaction.) Nor is it necessarily true that the non-conformist, the worker who eschews the pursuit of higher order needs, is mentally unwell; the situation is summarised by Locke who claims :

".... that satisfying and dissatisfying job incidents are not solely a reflection of 'human nature' as such, but that they also reflect differences in both the actual structure of jobs and people's experiences in different jobs." (Locke, 1973, p.76.)

The Limitations of Job Enrichment

It matters little to the application of the technique of job enrichment that the relationships between motivator and hygiene factors and job satisfaction and dissatisfaction are not as Herzberg originally claimed; improving the motivational content of a job should still produce better results than improving its hygiene context. The two factor formulation may have been reduced to one factor, but the motivator factors are simply more potent in overall effect than the hygiene factors. Suggestions that improving motivational job content will not invariably produce improved results, however, gave rise to the "contingency approach" outlined above, but other commentators have gone much further in illustrating the constraints upon the successful use of job enrichment.

Shepard (1974), while accepting the existence of a differential response to job enrichment, claims that the contingency approach may lead to :

1. the exclusion of urban-reared workers who would respond favourably to job enrichment,
2. a "blanket rationalisation" against implementing job enrichment at all, and
3. the probably false conclusion that negative attitudes of workers doing repetitive jobs would not change with knowledge and experience of job enrichment.

But other writers contend that the contingency approach does not go far enough and that job enrichment is of even more limited applicability. Maher (1971a) reports the only laboratory study of job enrichment encountered in the compilation of this review. His

results are somewhat ambiguous and his conclusion is in accordance with that of the contingency approach, that the technique is useful only in certain circumstances. Reif and Luthans (1972) and Little and Warr (1974) question its application to blue collar workers at all and argue that :

".... the evidence so far suggests that the approach is more readily applicable to administrative, clerical, supervisory and technical positions where there is inherently more scope for initiative." (Little and Warr, 1974, p.36.)

In addition, at least four typical worker reactions to job enrichment must be surmounted, claim Reif and Luthans (1972), for it to become a practical proposition, i.e. :

- (a) anxiety, when presented with new skills to learn,
- (b) fear, of failure and inadequacy,
- (c) increased reliance on supervision, at least initially, and
- (d) dislike of change.

Little and Warr (1974) also suggest that job enrichment is constrained to jobs at higher skill levels because -

- (a) some jobs are so routine and repetitive that increasing responsibility is impossible, and
- (b) workers on piece-work may regard job enrichment as an attempt at rate cutting.

The technique is constrained further, they argue by -

- (c) the instrumental attitudes of many workers towards work,
- (d) rejection of additional responsibility by those who feel stretched already,
- (e) the claim of some workers that their jobs are not as boring as outside observers think,
- (f) the expressed preference of some workers for simple

repetitive work, and
(g) managerial, supervisory and trade union resistance to
its implementation.

Successful applications it would seem, are therefore strictly situational. Robert H. Schappe (1974) from the Organisational Research and Development Department of General Motors, Detroit, provides an impressive list of "22 arguments against job enrichment", at the end of which one is left wondering how job enrichment could ever find application at all; but it has, on a modest scale, and this aspect will be dealt with shortly.

The Politics of Job Enrichment

Job enrichment is a management technique which attempts to improve productivity and reduce costs while leaving organisational structure intact. (Supervisory roles are altered when certain aspects of their work are given to their subordinates; the role of the supervisor alters, therefore, but the organisation chart remains the same.) Job enrichment does not have, (and indeed is not intended to have) any effect on the overall balance of authority within an organisation, workers may be given the opportunity to participate in management in only the most trivial sense, and the technique is, therefore, restricted to tinkering with the status quo. This limitation is surely one of the most obvious criticisms of job enrichment, but very few of those who work in the enrichment field have noted it. One exception is Ritti (1971) who argues (with particular reference to professional engineers and technicians) that unnecessary constraints are placed on the enrichment process in so far as organisation structure is left intact. Penzer (1973)

argues that within a year of having their jobs enriched, 200 clerical workers were again experiencing "the tedium of nine to five" and after their original enthusiasm for the concept, job enrichment had nothing more to offer them. Jenkins also supports this point of view, stating (although misusing the term "authoritarianism") that :

".... while such an approach is a worthwhile starting point, it is only a first step in eliminating the basic ills which arise from authoritarianism." (Jenkins, 1974, p.5.)

Critical also of the deliberate exclusion of worker involvement in the process, Jenkins argues :

"The way in which the job is enriched is decided, not by the employees concerned, but by the job enrichment experts. There is a fixed ceiling to the enrichment process, and when this ceiling is reached, it is finished. There is no provision for workers to discuss matters and propose improvements. Herzberg is against group action : Each individual is to be dealt with individually." (Jenkins, 1974, p.169.)

The popularity of the technique amongst American managers, claims Jenkins, is due to its being regarded as a "safe" technique, demanding no alteration to traditional hierarchical structures; when such alteration becomes imminent, the ceiling has been reached. For management, therefore, job enrichment may be regarded as a technique for maintaining the status quo in terms of distribution of power and authority in our organisations, and also as a technique for concealing or diverting attention away from other issues. Hughes and Gregory, for example, argue that the rejection of job enrichment by British trade unions is due to the fact that :

"They cannot forget other aspects of industrial life, including the social impoverishment and physical damage associated with low pay and excessive hours of work; with shift working; with industrial accidents, unemployment and job security." (Hughes and Gregory, 1974, p.387.)

An identical opinion is advanced by Dickson who states that :

"By placing relatively insignificant decisions in the hands of the worker, such as the rate at which he decides to work to meet a predetermined target, it is hoped that pressure will be taken off demands on significant issues, such as rates of pay, or the level of targets."
(Dickson, 1974, p.182.)

In spite of its humanistic underpinnings, the technique of job enrichment can thus be used by management as a political tool in attempts to mitigate the conflict of interests between management and labour. It may be used either to limit the grounds for discussion or to shift them into a different area. British trade unionists are probably more conscious of such managerial manoeuvres than their American counterparts.

One final criticism of job enrichment which provides an excellent illustration of the technique's apparent limitations is provided by Werther (1974); he points out that the predicted cost savings from job enrichment projects could more easily be achieved through the more extensive and imaginative use of part-time workers. The boredom and fatigue of some jobs can more easily be tolerated if the worker is not doing it all the time; there is no need to enrich such jobs if a flexible employment policy allows greater use of part-time workers.

The Practice of Job Enrichment

For the manager aspiring to the application of job enrichment in his own company advice is plentiful. Apart from original reports of job enrichment projects, there are a number of general reviews of selected projects, and much advice on "implementation strategies"; the latter are usually simplified for the practicing manager by

reducing exposition of the underlying theory to a bare minimum. The manager is advised to concentrate on the economic rather than upon the behavioural benefits to be gained from job enrichment (Whitsett, 1971); he is advised on how to overcome union resistance to its implementation (Myers, 1971); he may find that job enrichment can be as simple as the establishment of monthly "productivity committee" meetings (Scott, 1974). Reviews of projects tend to concentrate on a "core" of the better known and the better reported ones, some of which are mentioned below, and the "implementation strategies" generally follow the pattern suggested by Herzberg, often with more detail concerning, for example, the training of supervisors in motivation theory, or the running of "brainstorming" sessions. The advice offered by Ford (1969), and outlined below on p.110 is typical of many similar presentations, and other guides and reviews available include:

Smith,	1968	Walters,	1972
Broad,	1970	Greenblatt,	1973
Gooding,	1970(a)	Levinson,	1973
Gooding,	1970(b)	Mills,	1973
Butteriss,	1971	Organizational Dynamics,	1973
Dickson,	1971	Penzer,	1973
Maher,	1971(a)	Sirota,	1973(b)
Rush,	1971	Turner,	1973
Colosky,	1972	Yorks,	1973
Elliott,	1972	Tregoe,	1974
Grote,	1972	Maculoso and Taylor,	1975(?)
Sirota and Wolfson,	1972(a)	Walters,	1975
Sirota and Wolfson,	1972(b)		

The best of the above is that of Harold Rush (1971) whose concise and clear expositions of the theories of Lawler, Herzberg, Maslow and McGregor are presented along with seven case studies illustrating the varied application of available job design techniques. These studies are not all well known and include job enrichment projects carried out at Monsanto Chemicals, PPG Industries, Valley National

Bank, Weyerhaeuser, the Internal Revenue Service, Texas Instruments and Arapahoe Chemicals. On the other hand, Maculoso and Taylor (report undated, probably 1975) review a total of 87 "job enrichment" projects under the headings :

1. employee group
2. year initiated
3. number of employees affected
4. problem
5. technique used
6. human results
7. economic results
8. reference(s)

This paper is a valuable source of references but is apt to be misleading because :

- (a) all projects cited are described as "job enrichment" projects, no attempt being made to differentiate either between job enlargement and job enrichment, or between job restructuring and work organisation changes; and
- (b) reference to primary sources shows their analysis to contain a number of errors both of fact and of interpretation, many in the direction of overestimating the impact of the projects examined.

Emphasis is placed on the former point because Maculoso and Taylor are not alone in their lax use of the term "job enrichment".

The majority of the articles and books listed above are not of an academic nature (although this in itself is not a criticism), are repetitive in content, and frequently appear to have been written mainly to attract publicity. One is frequently left in some doubt as

to whether one has read an account of job enrichment or an advertisement for a firm of management consultants : David Sirota, for example, is Associate Professor of Management at the Wharton School, University of Pennsylvania, and he is also President of David Sirota Incorporated, Management Consultants; Lyle Yorks is Senior Associate with Drake-Beam Associates; Roy W. Walters works for Roy W. Walters and Associates; Benjamin Tregoe is a founder member of the consultancy firm of Kepner-Tregoe; William Penzer works with W.N. Penzer and Associates, and with its division Morale Incorporated; Lynda King Taylor is employed by PA Management Consultants Ltd. But whatever the source and quality of this work, it provides some indication of the extent of (at least American) management awareness of the job enrichment technique and the problems giving rise to it.

There are a large number of reports principally concerning specific job enrichment applications, but as mentioned above, many particular applications are described in a number of reports in varying amounts of detail and with varying accuracy. So to avoid a repetitious exposition of all these reports, the following procedure has been adopted :

1. two typical American and British job enrichment applications are described in some detail; these particular applications have been chosen because they are comparatively well known, and because they are fairly well reported;
2. a list of similar studies of reported applications is presented along with the names of some of the companies which have used the technique;
3. a brief critical summary of these reports is then given.

Ray Wild and his associates have conducted extensive reviews

and analyses of the literature on job design, producing a taxonomy of job design strategies within the basic theoretical dichotomy. Wild's work is considered in detail after the socio-technical systems design approach has been examined, and a more detailed analysis of the job enrichment studies is, therefore, inappropriate at this point.

Job Enrichment in America :
American Telephone and Telegraph (AT & T).

In "Motivation Through the Work Itself", Robert N. Ford (1969) describes 19 job enrichment projects carried out in the Bell system of AT & T between 1965 and 1969, affecting over 1000 jobs. The work was inspired by that of Herzberg, and the book not only describes the various projects (complete with the experimental controls proposed by Herzberg) but also presents substantiating results and offers advice and recommendation on how other companies should implement the "work itself approach" - i.e. job enrichment.

Employee dissatisfaction at AT & T appeared to be due to undesirable jobs, and job enrichment was considered to be an answer to the problem of the increasing costs associated with labour turnover. One of Bell's personnel men is quoted as having remarked "Our company has lost too many men who are still with us!" (Ford, 1969, p.16.) Of the 19 studies which Ford describes, 9 were considered "outstandingly successful", 9 were "moderately successful" and only one was a "flop". Overall the results included :

(a) reductions in labour turnover of job enriched ("achieving") groups, with turnover increases in control groups;

- (b) improvements, or at least no deterioration in, productivity, quality of performance and customer reaction;
- (c) 77 new applications subsequently started at time of writing;
- (d) over 50 companies outside Bell requesting information.

The two projects which Ford reports in the greatest detail will be examined here.

1. Shareholder Correspondents, Treasury Department, New York (Trial No. 1)

(Ford, 1969, Chapter 2, pp.20-44 and Appendix A, pp.203-208.

This is also the project which Herzberg used to illustrate his 1968 Harvard Business Review article. All page references in this and the following case study are to Ford, 1969.)

This was the original AT & T "work itself experiment" and it was conducted between March and September 1965. The group which underwent systematic job enrichment (the "achieving group") consisted initially of 28 female shareholder correspondents. Only 20 of these girls remained at the end of the study, but it is not clear what happened to the other eight; one, we are told, resigned (p.34), and Ford mentions that a larger proportion of promotions were being made from this group (p.35). Four other groups were involved in the study, a "telephone group" of 16 girls which was not set up as an achieving group but which experienced similar changes, a "control" group of 20 girls, and two "uncommitted" groups of 19 and 20 respectively. These figures indicate the group sizes at the end of the experimental period, the total group having been reduced from 120 to 95.

Ford lists five project objectives :

- "1. Improve the quality of service (we have an index).
2. Maintain or perhaps improve productivity levels.
3. Improve the turnover situation.
4. Lower costs.
5. Improve employee satisfaction in job assignments." (p.26)

Operators and first line supervisors were not, as Herzberg had advised, "in" on the project. Third and fourth level supervisors agreed on seven possibilities for change :

1. appointment of subject matter experts whom other group members could consult without going first to a supervisor;
2. correspondents could sign their own letters;
3. verification of work of experienced group members reduced from 100 to 10 per cent;
4. reduction in pressure for production from supervisors;
5. supervisors ceased to monitor outgoing work;
6. correspondents held fully responsible for the quality of work (previously shared with verifiers and supervisors);
7. "form-letter" approach discouraged, correspondents encouraged to reply in a more personalised manner.

(pp.29-30.)

These changes were introduced "quietly", after discussion with second-line supervision, at the rate of about one per week. No important changes were made to "hygiene" factors such as wages, hours of work, company policies, training, the physical work environment, or transfers of supervisors. It was in addition seen to be :

".... very important that none of the 14 first-level supervisors or their people was ever told that a study was in progress." (p.31.)

The results of the project fell under nine main headings and were as follows:

A. A "job reaction survey" was conducted in March and again in September 1965, using a simple 16-item scored multiple choice questionnaire. The achieving group average rose 15 points (from 39 to 54; maximum score is 80). The average of the control group dropped 4 points (from 41 to 37). The telephone group score rose from about 47 to 50, and the two uncommitted groups also remained about the same at between 40 and 45. (pp.31-33 and 37-39.)

B. A "customer service index" was prepared taking into account correctness of response, speed of response and accuracy of detail. This index was computed on a sampling basis and results were produced monthly for groups, not for individuals.

All groups showed an improvement on this index, the achieving and telephone groups being well ahead of the others. (The telephone group in fact came out best by about 5 points; maximum score is 100.) As predicted, the performance of the achieving group fell dramatically in May, but quickly recovered. (pp.32-34.)

C. Labour turnover was greatly reduced, but no data are presented to illustrate this claim. The one girl resigning from the achieving group did so because "She did not like the added responsibility and felt that other

- employees should verify a correspondent's work."
(pp.34-35.)
- D. Absenteeism had previously been an insignificant problem, running at around 2 per cent, and it remained so. (p.35.)
- E. Productivity is obviously difficult to measure in this kind of work but, although again there are no data given, previous levels appeared to have at least been maintained. (p.35.)
- F. Promotions were being made more frequently from the achieving and telephone groups (no data), but this may have been because the structure of the work now made it easier for supervisors to differentiate between the competent and the less competent correspondents. (p.35.)
- G. Cost reduction was not a major objective of the project, but it was estimated that over the first 18 months of the study \$558,000 had been saved. (p.44.)
- H. A number of "subjective results" are presented concerning the favourable attitudes of correspondents and supervisors to the changes. (pp.36-37.)
- I. Subsequent follow up study of the project over the next year indicated that the above results had not been transitory but had persisted. There was an increasing need to replace correspondents from the achieving group as experienced girls were promoted, and the customer service index stabilised at a very high level.

2. Framemen, Long Lines Department, New York
(Trial No. 14)

(Ford, 1969, Chapter 3, pp.51-60 and Appendix B,
pp.211 to 256.)

The Long Lines Department had a number of serious operating problems, for which job enrichment was again considered to provide a solution :

- "1. Low productivity.
2. High frame errors.
3. Due dates missed.
4. Circuits that did not meet quality standards.
5. High overtime.
6. Grievances." (p.52.)

The study commencing in January 1967, took place over eight months. Initially there were 40 framemen in the department employed in private line telephone circuit installation work -

"Within a huge central office, these men cross-connect wires of a long-distance switching point for telephone messages and many other kinds of communications."
(p.52.)

The framemen worked in teams of three, but the division of the work between team members was considered to be unsatisfactory :

"One worked at one end, soldering to a frame. The second ran the wire to a third man, who soldered the other end to a frame elsewhere in the huge building."
(P.52.)

Other craftsmen were responsible for translating the service order into instructions for the necessary frame work, and other "circuit test" groups checked the work of the framemen. The latter never knew whether a particular circuit was adequate, and the circuit test men never knew whose circuits they were checking. The framemen

spoke of themselves as "frame apes" and complained that the job required little ability and that anyone could do it.

The procedures for determining the changes to be made, and for implementing them, were similar to those described above for the shareholder correspondents. Based on a list of thirteen "greenlight" items, the change made was simply this : each team now does all the work from receiving the order to turning over the working circuit to the customer. This was expected to take at least two years, and Ford's report describes only the initial stages of the project. He describes the proposals thus :

"The two second level supervisors suggested combining the frame cross-connection group with the test group, dropping a cross-connection man, and adding a test man so that each three-man team has a test man on it from the start. (.....) Note that the supervisors plan eventually to collapse all five jobs so that every team has in it all five capabilities." (p.53.)

(The "five capabilities" are, respectively,

- private line service order
- loop testing
- circuit order write-up
- circuit testing
- cross connections.)

Individual differences in capability and aspiration, argued Ford, could be catered for in this way :

".... this approach, with its elastic job boundaries permits flexibility in dealing with people." (p.59.)

By the end of the initial eight month study period only 14 of the remaining 35 framemen had taken on even half of the new responsibilities offered to them, but encouraging results had nevertheless been achieved :

- A. The percentage of circuits completed on schedule increased, between January and September, from 50 per cent to 100 per cent. (pp.55-56.)
- B. The number of overtime hours worked fell by 50 per cent. (pp.56-57.)
- C. The number of circuit order items completed monthly rose from 700 to 1400. (pp.57-58.)
- D. The number of frame errors fell from 12 per cent to 3 per cent. (pp.58-59.)
- E. Union opposition precluded effective use of the "job reaction survey." (p.248.)
- F. Absenteeism did not alter over the study period. (p.249.)
- G. A number of subjective results are again cited indicating the favourable attitudes of supervision and framemen to the changes. For example :

"Now the men talk about 'my circuit' and 'my customer'. They established work priorities themselves and start the day immediately; no queuing up and waiting for the supervisor to give them work. And, when leaving a tour, they hand work directly to those coming in, which pleases supervisors too. Not only do the men enjoy checking circuits to see if they will meet test standards the first time; they are also asking when they will get certain new training." (pp.58-59.)

Other employees in nearby groups started requesting to be transferred to the frameman project.

Ford also includes in "Motivation Through the Work Itself" his ideas concerning "The Art of Reshaping Jobs" and "Following Through to an Improved Job" (Chapters 7 and 8 respectively).

He offers some detailed advice on the following points:

1. Selecting problem jobs.
2. Arranging workshops for appropriate managers to introduce motivation theory and "greenlight" lists of possible changes.
3. The organisation of "greenlighting" (or "brainstorming") sessions.
4. Determination of a "natural work module".
5. Evaluating suggestions in terms of both jobs and costs.
6. The importance of providing individual feedback to job incumbents.
7. Implementation of the job enrichment programme (in a two-phase, ten-step schedule).
8. Having supervisors implement the changes gradually.
9. Measurement and recording of results.

These two chapters present in detail a distillation of AT & T's practical experience of job enrichment over a period of 4 years. While clearly based on Herzberg's work, there is, however, one fundamental contradiction in Ford's "Motivation through the work itself": the final objective of Trial No. 14 is the establishment of composite autonomous groups of framemen in the Long Lines Department.

Job Enrichment in Britain : Imperial Chemical Industries (ICI)

W.J. Paul and K.B. Robertson in "Job enrichment and employee motivation" (1970) give accounts of eight job enrichment projects carried out in ICI in 1967 and 1968. Five chapters each describe

the application of the technique to a white-collar job, and one chapter ("Related shopfloor studies") briefly describes a further three blue-collar applications.

As with Ford, this was a direct application of Herzberg's theories and technique which meant that, throughout, "hygiene factors" remained constant, experimental and control groups were established in each application, and workers and first line supervisors were not privy to the knowledge that they were being experimented with.

Five white-collar jobs underwent enrichment - those of sales representatives, design engineers, experimental officers, draughtsmen, and production and engineering foremen. With the exception of the draughtsmen application, these projects are also described in Paul, Robertson and Herzberg, 1969. So here we shall examine the job enrichment of ICI draughtsmen, and one of the blue-collar applications which had not been implemented, but remained in the form of a proposal, at the time of writing.

1. Draughtsmen

(Paul and Robertson, 1970, Chapter 8, pp.56-61. All page references in this and the next case study are to Paul and Robertson, 1970.)

The routine nature of their work, and the frustrations generated by design modifications and delays, made job enrichment appear the ideal solution to the draughtsmen's problems. One unit, "K", was about to commence work on the design of a large new chemical plant, and this was designated the experimental group, comprising 21 draughtsmen. It was to be compared with a previous project of a

similar nature carried out by unit "J". (All the other projects used formal control groups to assess results, but this was not possible in this case.) The trial period in this case was from September 1967 to September 1968.

Three types of changes were made to the work of the draughtsmen. First, an attempt was made "... to weld the "K" unit draughtsmen into a composite task force for the project." (p.57) Specific measures adopted to achieve this were (p.57) :

1. locating the entire unit in one project office;
2. making demarcation boundaries flexible;
3. creating small sub-groups to deal with specific aspects of the project;
4. early appointment and involvement of the new plant's operating manager;
5. site visits by draughtsmen;
6. having draughtsmen on site to assist the construction.

Second, attempts were made to ensure that the draughtsmen were well briefed about the project through (p.57):

1. an initial briefing session on the "philosophy and objectives" of the design;
2. allowing draughtsmen to establish their own completion dates;
3. six-monthly interviews with section leaders to discuss work preferences and ambitions.

Third, a "selected group of senior designers" were given increased responsibility for (p.58):

1. costing designs;
2. specifying equipment;

3. Originating enquiries;
4. assessing tenders;
5. liaising with suppliers;
6. initiating materials requisitions.

There are no data presented in the evaluation of this project which is supported entirely by managerial judgement :

- A. No (anticipated) complaints arose when the entire staff was moved to inferior premises. (p.59)
- B. Flexible demarcation boundaries led to "... greater freedom of discussion and easier consultation" (p.59)
- C. The success of the initial briefing session led to subsequent ad hoc sessions being held. (p.59)
- D. The "selected few senior designers" who had been granted additional responsibility "... were said to have done it well." (p.60)
- E. Management believed that morale and team spirit were comparatively high in the "K" unit project. (p.60)
- F. A job satisfaction survey similar to that used by Ford indicated no significant changes in job satisfaction over the trial period, although the experimental group had increased its score slightly. (p.60)

2. Fitters and Operatives.

(Paul and Robertson, 1970, Chapter 10, pp.73-82.)

The "job restructuring" approaches to job design have been so named because their basic unit of analysis is the individual job.

This particular job enrichment proposal (it had not been implemented) is described here at some length because it contradicts that fundamental premise and deals instead with the work group as a whole. Paul and Robertson claim to have included it "... to illustrate the possibilities for job enrichment on the shop floor." (p.81)

Changes affecting the plant operatives were to have :

1. established self-supervising teams;
2. transformed the role of the foreman into a purely administrative one;
3. made the "leading hands" into team leaders and spokesmen.

It is worth noting in detail what these changes actually involved :

"Inspectors were to be eliminated from the teams; the men would be responsible for checking the quality of their own work at each stage of assembly, equipment being made available for this purpose. The men would be able to organise their own job rotation within the team and would have some say in recruitment into it. Teams would become responsible for their own stocks and material usages; they would also have authority to reject components unacceptable to them on grounds of quality. They were to be consulted on the design and methods of assembly of the products, and would be encouraged to make changes when appropriate. Their responsibility was to be extended to complement that of process operators in ensuring the correct use of the products in the plant: they would be given a regular feedback on performance, both good and bad, and would be sent to the plant to deal with complaints." (pp.81-82.)

The job changes proposed for individual fitters were as follows :

1. certain fitters were each to be mainly allocated to certain plants;
2. process staff could approach the fitter directly;
3. he would be consulted on design and quality of equipment purchased, constructed or used, and on arrangements for procuring spares;

establishment) of composite autonomous groups. In this respect, the applications of job enrichment described above are not entirely typical of job enrichment studies in general; of the 27 other job enrichment studies examined, 10 describe some form of group or team working changes :

Sorcher and Meyer, 1968	Taylor, 1972
Donnelly, 1971	Ford, 1973
Hays and Saballus, 1971	Gibson, 1973
Weed, 1971	Pythian, 1974
Sirota and Wolfson, 1972b	Jenkins, 1974

Other "orthodox" job enrichment studies (which include some well known company names) are to be found in the following :

Gomersall and Myers,	1966	
Sorcher and Meyer,	1968	(GEC - American)
Foulkes,	1969	(Polaroid, Texas Instruments)
Myers,	1970	
Janson,	1971	
Kraft,	1971	
Maher and Overbagh,	1971	
Mandle and Lawless,	1971	(Hoover)
Rush,	1971	(Monsanto Chemicals, Texas Instruments)
Employee Relations Bulletin,	1972	(Motorola)
Plant,	1972	
Powers,	1972	
Sirota and Wolfson,	1972(b)	
Taylor,	1972	(Volkswagen, Jensen, Shell UK)
Ford,	1973	
Harvey,	1973	(Meccano)
Novara,	1973	(Olivetti)
Sirota,	1973(a)	
Wade,	1973	(Renault)
Walsh,	1973	
European Industrial Relations Review,	1974	(United Biscuits)
Jenkins,	1974	(Several companies)

The job enrichment applications detailed above are typical in a number of other respects, and in summary, the following points may be said to apply to the technique in general :

1. there is some underlying confusion with regard to the precise nature of the technique in practice. This is partly

due to the tendency for the term "job enrichment" to be used to cover a variety of practices, but is also due to a more fundamental deviation from Herzberg's original formulation of the concept and its application to individual jobs;

2. both application and evaluation of the technique are subjective; the requirements of each situation determine the nature and extent of the changes made, and assessment of particular projects is generally based on management opinion;
3. the majority of reported case studies are non-academic in origin and content. A number consist only of descriptions of individual company experience, generally lacking any attempt at experimental control. Their results, such as they are, are not, therefore, cumulative;
4. the job enrichment technique makes no alteration to organisational structure, and a means of analysing its possible impact on organisation structure is lacking. The ambiguous position of first-line supervision which many of the case studies illustrate is indicative of this gap in the theory, as there is no method for systematically assessing in advance the effect of job enrichment changes for operatives on their supervisors. This constitutes an inherent weakness of job enrichment as a technique for organisational analysis and change;
5. as with job enlargement, increasing emphasis has been placed on the economic advantages of job enrichment rather than on the behavioural advantages. The following pessimistic

quotation from Whitsett, another American management consultant, aptly illustrates this trend :

".... I do not find that job satisfaction, improved job attitude, happiness or for that matter, mental health are saleable quantities in and of themselves. As a consultant, I have found it difficult, if not impossible, except in rare instances, to sell job satisfaction or mental health; so, I sell human resource utilisation in the form of job enrichment." (Whitsett, 1971, p.31).

Fourth Generation Theory : Expectancy Theory

Over the past ten or twelve years emphasis in work motivation research has shifted from two factor theory to "Valence - Instrumentality - Expectancy" theory, generally and more conveniently referred to as expectancy theory. Expectancy theory has a much lengthier pedigree than two factor theory and may be traced back to the utilitarian writings of Jeremy Bentham and John Stuart Mill. (Mill's essay on "Utilitarianism" was published in 1861.) Psychology as a science has developed out of philosophy, and as one illustration of this, the modern theories of learning and motivation which will concern us here clearly reflect these early influences.

Current theories of learning and motivation are not unified but are divided, generally, into two groups, each dominated by a different view of the nature of man:

"One represents man as being driven by inherited, conflicting, unconscious drives that cause him to behave in instinctual and, at times, self-destructive ways. The second view represents man as rational and aware of his goals and as behaving in those ways that he feels will help him achieve his goals."
(Lawler, 1973, p.4.)

These two groups of theories are commonly referred to as "stimulus-response" and "cognitive" theories respectively; the former considers that human behaviour is reflexive, the latter that it is goal directed or purposive. Expectancy theory is cognitive in its approach and was initially formulated by Edward C. Tolman, as a challenge to the stimulus-response theories of his contemporaries Clark Hull and Kenneth Spence:

"The expectancy theories of Tolman and (Kurt) Lewin picture behaviour as being determined by people's goals

and the expectancies people have that various behaviors will lead to the goals. The drive theories of Hull and Spence emphasise that behavior is determined by drives and by learned associations between situation and behavior." (Lawler, 1973, p.4.)

Drive theory is simply another name for stimulus-response theory. A more detailed treatment of this aspect of the topic may be found in Lawler (1971, Chapters 5 and 6; 1973, Chapters 2 and 3) who compares in detail the respective attributes of drive theory and expectancy theory, and discusses the advantages of the latter with respect to the explanation of work motivation. A detailed exposition of Tolman's expectancy theory, and a summary of current developments which reflect his influence, is to be found in Hilgard and Bower (1975, Chapter 5).

In the field of work motivation, early support was provided for this approach by Georgopoulos, Mahoney and Jones (1957) who developed what they termed a "path-goal approach to productivity" for their study of some 620 workers in a household appliances company. The assumptions upon which their model is based illustrates its nature as an expectancy theory :

".... individual productivity is, among other things, a function of one's motivation to produce at a given level; in turn, such motivation depends upon (a) the particular needs of the individual as reflected in the goals towards which he is moving, and (b) his perception regarding the relative usefulness of productivity behavior as an instrumentality, or as a path to the attainment of these goals." (Georgopoulos et al, 1957, p.238 in Vroom and Deci, 1970.)

Expectancy theory thus hopes to explain why (all other things being equal) individuals are motivated to produce at different levels. Motivation is hypothesised to depend upon the outcomes which a person values and upon his expectation that a particular level of performance will lead to those outcomes. An individual

will, therefore, tend to produce more if high productivity is seen as leading to the attainment of valued goals. Conversely, if low productivity is seen as leading to valued goals, the individual will tend to produce less. From their research questionnaire, Georgopoulos, Mahoney and Jones found that workers with a "positive path-goal perception" (i.e. high productivity leads to valued goals) tended to produce at a higher level than workers with a "negative path-goal perception" (i.e. low productivity leads to valued goals). The goals which appeared to be particularly important for this group as a whole were -

- making more money in the long run,
- getting along well with the work group,
- promotion to a higher base rate.

Ten such job-related items were used, we are not told what the other seven were, and no selection criteria for the ten items are described. Vroom (1962) criticised Georgopoulos et al for their preoccupation with immediate, extrinsic, rewards arguing that reward values of all the anticipated consequences of a level of performance should be taken into account as well as the immediate reward value itself in an explanation of work motivation.

Victor H. Vroom (Professor of Industrial Administration, Carnegie-Mellon University, Pittsburg) is in fact accredited with having provided the first systematic formulation of an expectancy theory of work motivation (see Lawler, 1973, p.45). For Vroom (1964), the preference which an individual has for a particular goal or goals is termed "valence", defined as "affective orientations toward particular outcomes" (p.15). Valence refers to the anticipated rather than the actual satisfaction to be gained from an

outcome, and it may, therefore, be negative, neutral, or positive.

In Vroom's expectancy equation, it can take on a value between -1 and +1. The (subjective) probability that a given act will lead to a particular outcome is termed an "expectancy", which may, therefore, be given a value between 0 and 1. The "force", or motivation, to perform an act is thus a function of both valence and expectancy, and Vroom expresses this relationship as -

$$F = E \times V$$

Where F = force to perform an act,

E = the expectancy that the act will be followed by a particular outcome, and

V = the valence of the outcome.

Since in most situations a number of outcomes will result from a particular act, the equation should be summed across all of them, and the final version of the relationship is therefore -

$$F = \sum (E \times V).$$

Expectancy and valence are hypothesised to combine multiplicatively because when either is zero, force, or motivation, will also be zero, and this is in accord with common sense: if a person perceives a very high probability that a particular act will lead to a particular outcome, but he places no value on that outcome, there will be no motivation to perform the act. Conversely if a person places a high value on a particular outcome but perceives no probability of his effort attaining it, motivation will again be zero. Only when both terms are positive will motivation be positive. Expectancy and valence combined additively would produce different predictions, and this is rejected as unrealistic.

Expectancy theory is thus a type of hedonism; it postulates that individuals strive towards outcomes which they anticipate will bring them pleasure, and avoid outcomes which may produce discomfort or pain. Handy (1976) refers to the expectancy equation as the "motivation calculus" (p.33); while dealing with subjective perceptions of situations the theory imparts at least a kind of rationality to man's decision making with regard to his behaviour. It should also be noted that as a general theory of motivation, expectancy theory can deal with why people eat ice-cream or go ballroom dancing as well as with behaviour at work. It is, of course, only the latter aspect with which we shall be concerned here.

Following Vroom's formulation, expectancy theory has been subjected to significant modification and development, and to numerous empirical tests of its validity. Empirical tests of the theory have tended to become increasingly complex due to the growing number of variables which appear to have to be taken into account in attempts to improve its predictive power. In both the development and testing of expectancy theory, the contribution of one American researcher has been particularly significant - that of Edward E. Lawler III, currently at the University of Michigan. Lawler has also been responsible for pursuing the implications of expectancy theory in the field of job design and it is this aspect of his work which is of most concern here. Lawler is a prolific writer and only a sample of his work, and that of his colleagues, is mentioned here.

Lawler makes two main criticisms of Vroom's exposition of expectancy theory. First, Vroom does not discuss the particular rewards which human beings may consider as relevant outcomes of behaviour. Second, Vroom confuses the act of behaviour with its

outcome or outcomes, when these are conceptually distinct from one another; a person attempting to perform well does not necessarily perform well as a result, and Lawler's formulation of the theory attempts to take account of this. With regard to the first criticism, Lawler and Porter (1967) suggest that emphasis be placed on the hierarchical list of needs given by Maslow (1943, 1970). A subsequent, more comprehensive, review of the literature on this subject prompted Lawler (1973) to suggest the following list of human needs which appeared to be particularly relevant to the work situation :

- "1. A number of existence needs - primarily sex, hunger, thirst, and oxygen.
2. A security need.
3. A social need.
4. A need for esteem and reputation.
5. An autonomy or freedom need.
6. A need for competence and self-actualisation."

(p.32)

Lawler further suggests that these needs are arranged in a two-step hierarchy (in contrast to Maslow's original five-step hierarchy). The higher order needs, Lawler suggests, do not come into play until existence and security needs have been satisfied, but he claims that there is little evidence to indicate that the higher order needs are themselves hierarchically organised. With regard to the criticism that acts and outcomes tend to be confused, Lawler and Porter (1967) define expectancy, or "effort-reward probability" as

"... an individual's subjective expectancy about the likelihood that rewards that he desires will follow from putting forth certain levels of effort, and is similar to the concept of subjective probability. Such an expectation can be thought of as representing the

combination of two separate subsidiary expectancies, namely; (a) the probability that rewards depend upon performance; and (b) the probability that performance depends upon effort." (Lawler and Porter, 1967, p.257 in Vroom and Deci, 1970.)

Two types of expectancy are, therefore, postulated - the probability that performance leads to reward (the "instrumentality" term) and the probability that effort will lead to performance or accomplishment of what is attempted. Lawler and Porter's complete model is shown in Figure 2.4. Two obvious mediators of the relationship between effort and performance are shown, the individual's ability and his perceptions of his role. In subsequent research, Lawler (1968) claimed to have shown that expectancy attitudes do in fact determine performance; the possibility that the reverse holds, i.e. that performance determines expectancy attitudes, is ruled out.

An example of the way in which the model's components can be operationalised in order to test the theory is given by Hackman and Porter (1968), and this practical illustration also serves to provide a clearer idea of the nature of expectancy theory. Hackman and Porter set out to test the ability of expectancy theory to predict the work effectiveness of 82 telephone company service representatives (female) using Vroom's formulation of the theory,

$$F = \sum_{i=1}^n E_i \times V_i,$$

where n is the number of possible outcomes. In order to determine the employees' motivation levels, therefore, three types of information had to be obtained:

- "(a) a list of outcomes which they expect to obtain as a result of "working hard" on the job;
- (b) an estimate of the level of certainty they have that outcomes will in fact be obtained as a result of working hard (E_i); and

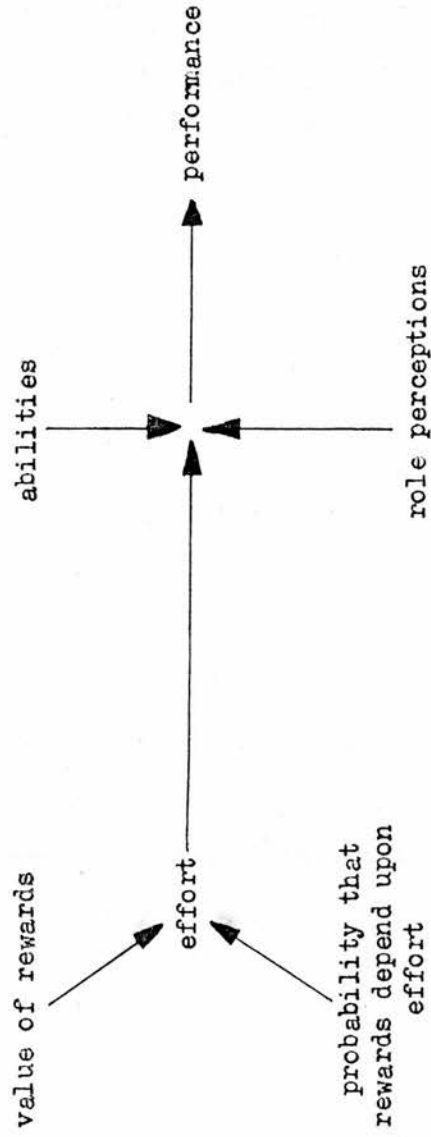


Figure 2.4: The expectancy theory of Lawler and Porter (1967).

- (c) an estimate of the degree to which they like or dislike the outcomes (V_i)." (Hackman and Porter, 1968, p.418.)

Hackman and Porter argue that obtaining a list of expected outcomes is simplified if only those beliefs which are held in common by a group are taken into account, because this procedure does not affect the level of prediction. They therefore interviewed two dozen service representatives and the 14 outcomes mentioned by 3 or more of the interviewees were then taken to represent the group's expected "consequences of working hard". These beliefs range, for example, from "Time will seem to go faster", through "She is likely to gain admiration and respect from her fellow workers" to "She is likely to receive a raise more quickly". Four "moderately negative" beliefs were added to the list by the researchers, and the complete list of 18 items is to be found in Hackman and Porter (1968), p.421.

A questionnaire was then administered to the service representatives to obtain indices of expectancy (E_i) and valence (V_i). To measure expectancy, they were asked questions in the format:

"If a person works especially hard on this job, she is more likely to feel a sense of completion and accomplishment at the end of the day." (p.420)

Answers were indicated on a seven point scale, ranging from "not at all true" (i.e. the employee did not expect that working hard would lead to this outcome) to "very true". Valence was measured in a similar manner, the outcomes themselves (e.g. "feeling a sense of completion and accomplishment") being rated on a seven point scale ranging from "very good" to "very bad" with "neither good nor bad" at the midpoint.

The outcomes which employees consider to result from working

hard on the job have been determined, and the expectancy and valence terms have been operationalised and measured. All that remains is to enter the values obtained into the expectancy equation ($\sum E \times V$) for each individual to determine her motivation (F). At this point, however, the authors consider it necessary to enter a footnote bringing attention to the fact that the measurement processes do not meet the criteria for ratio scales. (They do not in fact meet the criteria for an interval scale either.) The argument used to circumvent this problem is that:

".... the predictor is viewed as a numerical score which, given the measurement and arithmetic operations employed to obtain the score and the theory from which the operations were derived, should reflect gross differences in the motivation of subjects to work hard. (.....) such procedures are reasonable, as long as the scores are substantively meaningful on extramathematical grounds and so long as the scores do in fact relate to the criterion variables of interest." (p.421)

This "ratio scale problem" (see Locke, 1975, p.464) applies to all attempts to operationalise the theory's components, regardless of the precise nature and definition of the variables used.

The next step in the research was to correlate the motivation score of each individual with each of five performance criteria:

1. Job involvement and effort; determined by supervisory ratings on four scales.
2. An employee appraisal form; part of the company's standard appraisal system, again using supervisory ratings this time on seven scales.
3. Error rate)
) from company records.
4. Sales data)
5. A composite criterion based on criteria 1, 3 and 4 above.

The expectancy predictor ($\sum E \times V$) correlated .40 with the composite

criterion, number 5, and smaller positive correlations were obtained for the other criteria. These results thus provide some evidence of the predictive properties of the theory. Hackman and Porter go on to suggest that the theory indicates three changes in organisational practice which should lead to improved performance:

- "(a) instituting new outcomes which will be valued by the performer and which will be seen by him as resulting from hard work;
 - (b) changing the expectancies of existing outcomes so that the link between hard work and positively valued outcomes is strengthened and that between hard work and negatively valued outcomes is weakened; and
 - (c) changing the valences of existing outcomes."
- (Hackman and Porter, 1968, p.425.)

The first two of these, it is pointed out, are more amenable to manipulation than the third.

Hunt and Hill (1969) briefly examine the results of four other studies which provide support for the predictive potential of the theory. Graen (1969) and Mitchell and Albright (1972) illustrate the trend mentioned above for empirical tests of the theory to become more complex. None of these reports is of particular relevance to the topic in hand and further explication of their content would require a lengthy and somewhat unnecessary digression. Hackman and Porter's (1968) research is a good illustration of expectancy theory in practice, but it incorporated neither of the modifications suggested by Lawler and Porter (1967). There are different interpretations placed upon what expectancy theory actually should be. As a representative of the current status of the theory, Lawler's account appears to be the most comprehensive, and lucid, available. What is here described as fourth generation theory, therefore, is illustrated in Figure 2.5, from Lawler (1971). This

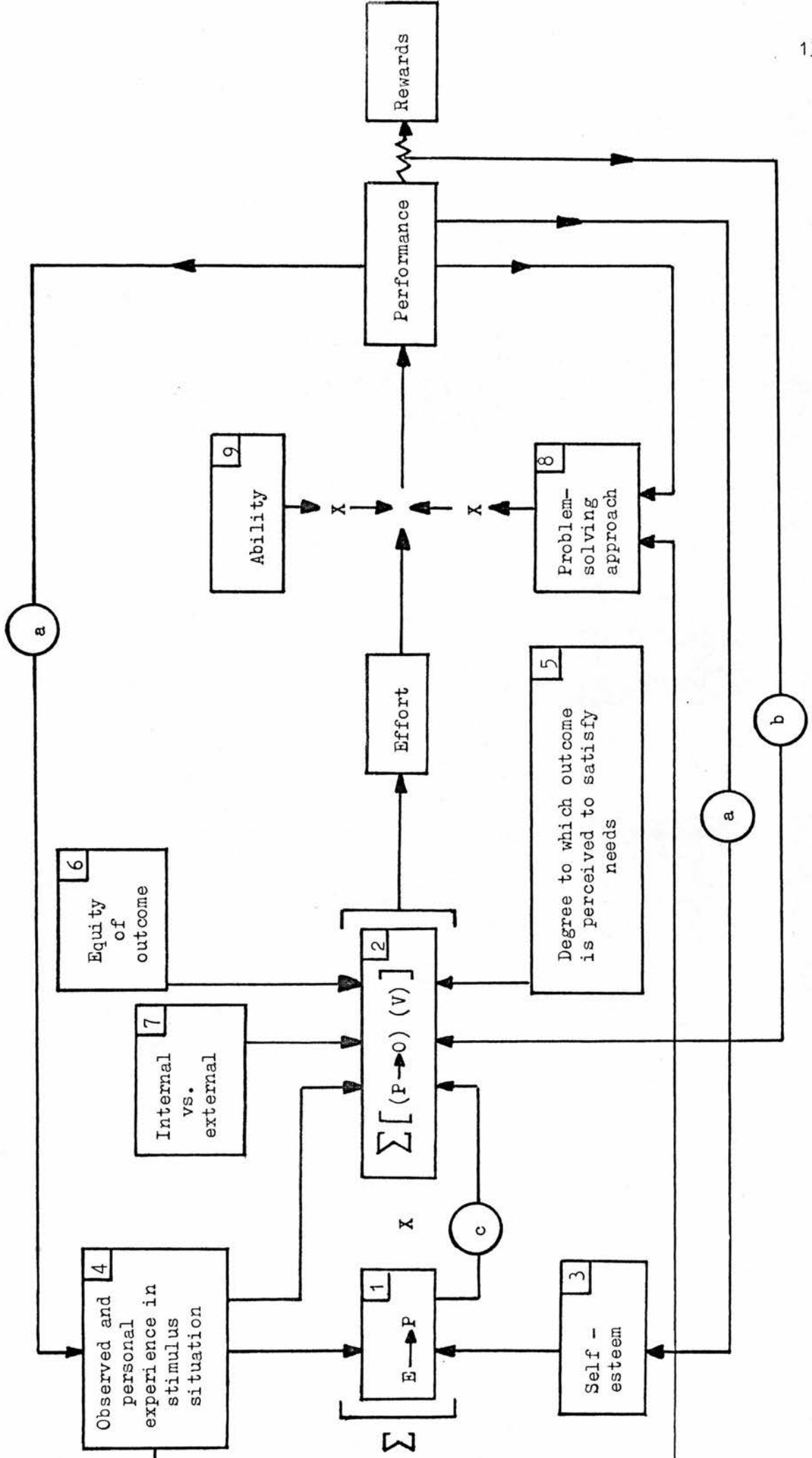


Figure 2.5: Lawler's "motivation model"; fourth generation theory (from Lawler, 1971, p.108).

particular model is an undoubtedly popular one, but it is given here as a representative of its kind and significant variants of the theory are used.

Vroom argued that outcomes achieve valence through their perceived relationship to ends; outcomes leading to desirable consequences are positively valued, those leading to undesirable consequences will be negatively valued. He did not say which ends or consequences could be desirable or how an end or consequence came to be desirable. Lawler, as mentioned above, chooses to rely on a number of content theories of motivation, mainly that of Maslow (1943), which are directed at this question. From Figure 2.5 it will be seen that (for Lawler) the individual's motivation to perform at a given level is determined by two variables:

1. "... the person's belief concerning the probability that if he puts effort into performing at that level, he will be able to perform at that level (Box 1)." (Lawler, 1971, p.107.)

This belief is a subjective probability and can, therefore, vary from 0 to 1.

This belief is influenced by two factors, self-esteem (Box 3) and previous experience (Box 4). Self-esteem and previous experience are in turn both influenced through time by feedback concerning job performance (loop a). Thus,

".... the higher the person rates his self-esteem and the more he has been able to perform effectively in similar stimulus situations, the higher will be his effort → performance (E → P) subjective probability."
(Lawler, 1971, p.107.)

2. "The second factor that influences motivation is really made up of a combination of beliefs about what the outcomes of accomplishing the intended level of performance will be and the valence of these outcomes (Box 2)." (Lawler, 1971, p.108.)

This gives the term $\sum [(P \rightarrow O) \times (V)]$, where $P \rightarrow O$ is the probability that performance will lead to a particular outcome, and V is the valence of that outcome. The term is summed across all possible outcomes. Valence can take on a value between -1 and +1, and the term $P \rightarrow O$ is another subjective probability - the "instrumentality" term - and, therefore, has a value between 0 and 1.

If only one $E \rightarrow P$ probability were to be taken into account (the probability that trying to perform at a particular level will lead to performance at that level), the equation would simply read:

$$F = (E \rightarrow P) \times \sum [(P \rightarrow O)(V)] .$$

It has been noted, however, that trying to perform at a particular level does not necessarily produce that level of performance. If the $E \rightarrow P$ probability is less than 1, therefore, it may be necessary to consider the probability that trying to perform at a particular level will lead to performance at a different, presumably lower, level. Such an additional $E \rightarrow P$ probability would then be combined with the respective $(P \rightarrow O)(V)$ values for that level of performance. This is the reason for the sigma sign preceding the first term of the equation (Box 1). The necessity for taking into account additional $E \rightarrow P$ probabilities is illustrated by the situation in which strong negative consequences are likely to result from poor performance. Regardless of the positively valued outcomes of successful performance, motivation may be significantly reduced if failure to perform at the intended level is seen as leading to substantial negative outcomes.

The model (Box 7) shows motivation to be affected by the extent to which an individual believes that he can influence outcomes and events personally (internal control) or whether outcomes and

events influence him (external control). (See Lawler, 1971, p.110 or Lawler, 1973, p.57.) Feedback loop b allows for possible learning of performance \longrightarrow outcome probabilities over time.

Paradoxically, it need not be the case that motivation is highest when $E \longrightarrow P$ probability is high; no great value may be placed upon the performance of acts which are easy to perform well, where effort is certain to lead to good performance. Feelings of achievement and accomplishment may be aroused more when the $E \longrightarrow P$ probability is around 0.5. The $E \longrightarrow P$ term thus has an influence on the $P \longrightarrow O$ term and this is indicated by the line marked c.

Effort and ability (Box 9) are hypothesised to combine multiplicatively, for precisely the same reason that the expectancy theory's main components are combined in that manner; if either effort or ability is zero then performance will be zero.

Box 8 refers to what has previously been called role perceptions - "the person's perception of how his effort can best be converted into performance." (Lawler, 1971, p.113.) This is again shown as combining multiplicatively with effort since if role perceptions are inaccurate, performance will be low (or zero) regardless of effort expended.

The valence of outcomes is seen to be influenced by the extent to which they satisfy the individual's needs (Box 5) (and here Lawler is referring to his two-step need hierarchy), and by the extent to which the individual's input (effort) - outcome balance is perceived to be just (Box 6). This latter proposition is derived from equity theory; (this is discussed at length in Lawler (1971) Chapter 5, and Lawler (1973) Chapter 2).

In his more recent book, Lawler (1973) summarises the theory with some minor changes in emphasis. He gives the following lists

of the determinants of $E \rightarrow P$ and $P \rightarrow O$ expectancies:

Determinants of $E \rightarrow P$ expectancies (p.55)

- Self-esteem
- Past experience in similar situations
- Actual situation
- Communications from others

Determinants of $P \rightarrow O$ expectancies (p.58)

- Past experience in similar situations
- Attractiveness of outcomes
- Belief in internal versus external control
- $E \rightarrow P$ expectancies
- Actual situation
- Communications from others

The "Actual situation" and "Communications from others" appear to be new terms incorporated into the model.

The complexity of expectancy theory has led a number of critics to question the extent to which the individual either carries out the analysis implied by the theory before undertaking some particular behaviour, and to what extent the individual is indeed capable of making such calculations. This is not of great importance since, if the theory is shown to be an accurate predictor of performance, it will be enough to say that the individual makes decisions with regard to his behaviour as if the expectancy equation had in fact been worked out. Lawler, however, stresses that man's rationality, while evident, is limited, and that behaviour exhibits "satisficing" (after Herbert Simon) rather than "maximising" characteristics:

"It must be remembered that man bases his behavior on perceptions that are simplified and that he does not

consider all factors. Thus, carried to all its permutations and combinations, our model would undoubtedly be much more complicated than the models that people actually use. The model of course does not have to be carried to all the combinations. It can be viewed as considering a limited number of alternatives, just as people do. The important thing the model does is to show the kinds of cognition people have and how these interact to influence behavior." (Lawler, 1971, p.116.)

Expectancy Theory and the Design of Jobs

Lawler initially argued that job design changes influence motivation through their potential effect upon $P \rightarrow O$ beliefs:

"They can do this because they have the power to influence the probability that certain rewards will be seen to result from good performance, not because they can influence the perceived probability that effort will result in good performance." (Lawler, 1969, p.162 in Vroom and Deci, 1970.)

Lawler has revised this view and has indicated that job design changes may influence all three components of the expectancy model : $P \rightarrow O$ beliefs, outcome attractiveness, and $E \rightarrow P$ beliefs. (Lawler, 1973, Chapter 7.)

With regard to effect on $P \rightarrow O$ beliefs, job design determines not only the kinds of rewards that are available, but also what the employee must do in order to obtain these rewards. Job design changes can potentially increase performance by influencing an individual's beliefs concerning the outcome of good performance. Intrinsic rewards, claims Lawler, are more important in this respect than extrinsic rewards because the relationship between good performance and intrinsic rewards is more direct than that for extrinsic rewards.

With regard to outcome attractiveness, an individual discovers the outcomes of task performance through performing various kinds of

task. The design of the job or jobs which an individual does can therefore have a bearing on which outcomes come to be valued by the individual. Lawler cites evidence to suggest that certain kinds of task can arouse latent (or dormant) achievement motivation in some individuals, leading in effect to a change in an individual's motivational state.

With regard to E \rightarrow P beliefs, job design can affect the perceived relationship between effort and good performance. On many tasks, e.g. those on an assembly line, the relationship between an individual's effort and performance is a fairly clear one, most people being able to perform such tasks successfully. With some managerial jobs, on the other hand, expenditure of effort does not guarantee good performance and the relationship between the two is not so visible.

From examination of previous research (his own and that of others), Lawler claims to have identified three job characteristics which have a significant influence on the motivation to work; in particular, he hypothesises that:

".... satisfaction should be obtained when an employee works effectively on a job that (1) allows him to feel personally responsible for a meaningful portion of the work, (2) provides outcomes that are intrinsically meaningful or are otherwise experienced as worthwhile, and (3) provides feedback about what is accomplished."
(Lawler, 1973, p.158.)

It is not an objective assessment of the job which is important in this respect but the individual's perception of his job in these terms. Individuals react to job characteristics in different ways, and Lawler argues that the main determinant of such individual differences is higher-order need strength. Jobs which are rich in the three characteristics mentioned are more likely to motivate, and satisfy, those

individuals who value intrinsic outcomes such as feelings of accomplishment, growth or competence. Individuals who do not value these outcomes are likely to respond to such comparatively demanding jobs with irritation and frustration.

In order to measure jobs using the three characteristics given, Lawler used four of the attributes on the Turner and Lawrence (1965) Requisite Task Attribute (RTA) index (see p.66 above):

- autonomy
- task identity
- variety
- feedback

These are referred to as the four core dimensions of job design and their precise derivation is described in more detail below.

To summarise so far, the theory predicts that the greater the individual's higher-order need strength and the job's ratings on the four core dimensions, the higher will be the individual's motivation, performance and satisfaction. Note that here satisfaction is said to depend upon performance, not vice versa.

An attempt to test this theory is reported by Hackman and Lawler (1971). The subjects of their study were 208 telephone company employees working in 13 different jobs. Two independent variables were examined; (a) strength of desire for satisfaction of higher order needs, and (b) descriptions of the 13 jobs in terms of the four core dimensions (autonomy, task identity, variety and feedback). It was predicted that when a job is rated high on the four core dimensions, employees having a strong desire for higher order need satisfaction would tend to have high motivation, high job satisfaction, be absent infrequently and perform better.

Hackman and Lawler considered that the measurement of individual differences directly would be of greater value than the examination of subcultural variables. Blood and Hulin (1967), as mentioned above (see p.92), had previously applied this criticism to their own research concerning the apparent effects of subcultural variables. In adopting this approach, however, Hackman and Lawler admit one problem, in that:

".... it requires prior specification on a conceptual level of what specific differences among people are responsible for the results reported by Turner and Lawrence (1965) and Blood and Hulin (1967), i.e. what is it about people that moderates the way they react to their jobs." (Hackman and Lawler, 1971, pp.261-262.)

Their conceptualisation of this interaction between job characteristics and individual differences is based upon five propositions derived from expectancy theory, dealing with the influence of job design on employee motivation. These are, briefly:

1. An individual will undertake those behaviours which he believes will lead to valued (intrinsic and extrinsic) outcomes.
2. The outcomes which are valued are those which lead to satisfaction of physiological and psychological needs, or which lead to other outcomes which are expected to satisfy such needs.
3. Employees will, therefore, tend to work hard if jobs are such that their needs can be satisfied by working hard.
4. Lower level needs (physical well-being, security) are generally fairly well satisfied in our society, but higher order needs (personal growth, accomplishment feelings) are not always satisfied to the same extent.

5. Higher order need satisfaction is achieved through accomplishment of something worthwhile or meaningful for the individual. To arouse intrinsic motivation, a job must be high on all four core dimensions.

Hackman and Lawler in fact measured six of the job dimensions from the RTA index:

Variety:

"the degree to which a job requires employees to perform a wide range of operations in their work and/or the degree to which employees must use a variety of equipment and procedures in their work."

Autonomy:

"the extent to which employees have a major say in scheduling their work, selecting the equipment they will use, and deciding on procedures to be followed."

Task identity:

"the extent to which employees do an active or whole piece of work and can clearly identify the result of their efforts."

Feedback:

"the degree to which employees receive information as they are working which reveals how well they are performing on the job."

Dealing with others:

"the degree to which a job requires employees to deal with other people (either customers, other company employees, or both) to complete the work."

Friendship opportunities:

"the degree to which a job allows employees to talk with one another on the job and to establish informal relationships with other employees at work."

(Hackman and Lawler, 1971, p.265.)

The last two dimensions are based on the RTA index dimensions

"required" and "optional" interaction respectively. Questionnaire measures of each of the dimensions were developed; these are based on employees' subjective assessments of task characteristics. Objective

(i.e. researcher) ratings on these measures were also obtained and a high degree of correlation was found between the two sets of results (except for ratings on the "feedback" dimension which appears to have been ambiguously defined). Hackman and Lawler then correlated ratings of each of the dimensions with the dependent measures of satisfaction, performance and absenteeism, controlling for need strength which was also measured by questionnaire. (Their measure of desire for satisfaction of higher order needs was developed "on an a priori basis".) The relationship between perceived job characteristics and behavioural and attitudinal reactions of employees was then examined for each of the 13 jobs, and the hypothesis that only jobs rated highly on the four core dimensions are conducive to high satisfaction and performance was tested.

Hackman and Lawler found that the employees who rated their jobs highly on the core dimensions tended to do higher quality work, were regarded as more effective performers, and reported "feeling internal pressures to take personal responsibility for their work" (p.273). Jobs rated highly on the core dimensions were also related to overall job satisfaction, and to lower absenteeism. Four satisfaction items in particular were related to the core dimensions: (in descending order of strength)

- opportunity for independent thought and action,
- feeling of worthwhile accomplishment,
- opportunity for personal growth and development,
- self-esteem and self-respect attached to the job.

The four satisfaction items least strongly related to the core dimensions were: (in ascending order)

- pay,

- opportunity to develop close friendships,
- opportunity for promotion,
- respect and fair treatment from superior.

The hypothesised relationship between the core dimensions and the satisfaction of higher order needs (the fifth proposition of Hackman and Lawler) is thus given substantial support by this set of results.

Neither of the interpersonal relationships - "dealing with others" and "friendship opportunities" - showed any strong or consistent relationship to attitudes or to performance. The researcher's explanation for this is that the consequences of jobs rated highly on these measures are primarily social in nature, and they are not, therefore, relevant to motivation and performance.

In summary, Hackman and Lawler had proposed the following "scenario":

- (a) jobs rated highly on all four core dimensions
performed by
- (b) individuals with strong higher order need strength
lead to
- (c) the experience of pressure to take responsibility for one's own work
and also to
- (d) high intrinsic motivation,
- (e) high performance quality and performance effectiveness,
- (f) high job satisfaction and job involvement, and
- (g) low absenteeism.

Generally speaking, all of these expectations were supported by the results of the study, except for that concerning absenteeism where the differences observed were in the expected direction but were not

statistically significant.

Overall, the results of the research of Hackman and Lawler (1971) provide impressive support for their expectancy theory of job design. Not so impressive, however, is their first job design project which attempted to test the theory in practice (Lawler, Hackman and Kaufman, 1973). (This study is also summarised in Cameron, Orchin and White, 1974.) The project was carried out in the company in which Hackman and Lawler had conducted their earlier (1971) research. The researchers' previous involvement in the company had stimulated this project which was reported as a test of the theory that had been developed. The job design changes affected female telephone operators whose office was originally organised in the following way:

<u>Job Title</u>	<u>Number</u>
Chief Operator	1
Group Chief Operators (GCO's)	7
Service Assistants (SA's)	14
Operators	39

There were two types of operator job; the "directory assistance" job which involves what we would call "directory enquiries", and the "toll" job, which involves placing, timing and charging long distance calls. All employees up to CGO level were given a revised version of the questionnaire used by Hackman and Lawler in 1971, 2 weeks before any changes were made, and again 6 months afterwards. Due to turnover and scheduling problems, only 17 operators completed the questionnaire on both occasions. Unstructured interviews were also held with all the GCO's, 5 SA's and 8 operators.

The changes took place under the name "Initiative and Judgement

Programme", and this was conducted by two members of the company's staff. Operators and SA's were not involved in the redesign process. The changes which took place were as follows:

1. Operators were given more freedom to choose what phraseology to use with customers, instead of being restricted to a number of set phrases.
2. Operators were allowed to omit reference to their operator number at the start of each call.
3. Operators were allowed to leave their stations to check records and look up non-public numbers without obtaining their supervisor's permission.
4. Directory assistance operators were free to assist on the toll job at their own discretion if the latter appeared to be overloaded.
5. Operators were free to service a customer who had a large number of requests at their own discretion, or to call the customer back when the work load fell.
6. Operators were free to visit the ladies' room without the supervisor's permission and without signing out on a blackboard.
7. Operators themselves reported the numbers of calls they had handled.

The immediate effects of these changes comprised a reduction in the training time for directory assistance operators from 5 days to 2, and major changes in the Service Assistants' jobs. The latter now spent much less time on "minute - by - minute" office management and on operator training than they had previously. One of the main results of the study is illustrated in Figure 2.6. The directory

assistance job appeared to have been changed on only two of the four core dimensions - variety and autonomy. The absolute level of the job on these two dimensions, however, was still low even after the changes, in comparison with the 13 other jobs in the company which had previously been studied. (The toll job had remained unchanged, and this was verified by the operators' ratings.) No significant changes were found in the SA's ratings of their jobs on the core dimensions.

Characteristic	Before	After
Core dimensions:		
Variety	1.90	2.60*
Autonomy	2.63	3.56*
Task identity	5.80	6.12
Feedback (from work itself)	4.63	4.72
Feedback (from management)	4.13	4.76

* Statistically significant

Figure 2.6: Operators' ratings of directory assistance job (based on Lawler, Hackman and Kaufman, 1973, p.54).

The increased motivation and satisfaction expected from the changes to the directory assistance job did not occur, and satisfaction with interpersonal relationships decreased significantly. The SA's also indicated decreased satisfaction with the items concerning:

"(a) a stimulating and worthwhile medium of expression; (b) satisfying interpersonal relationships; and (c) job security." (Lawler, Hackman and Kaufman, 1973, p.57.)

These results were apparently not due to low higher order need strength, but data on tenure showed longer serving employees to be generally more dissatisfied with the changes than comparatively new employees.

Lawler et al attribute failure of the project to two major factors;

first, even after the changes had been made, the job of directory assistance was still comparatively low on the four core dimensions; second, the changes affected only two of the four core dimensions, and the theory requires improvement in all four simultaneously. Altogether, therefore, it was not surprising that the changes had no significant effect on intrinsic motivation.

Of more interest, perhaps, was the effect of the changes on the SA job:

"When the operators began performing some of the tasks that previously had been done by the SA's, existing relationships between operators and SA's apparently were severely disrupted. No longer did the SA's make many decisions for the operators, and no longer did the operators come to them with their problems. This decreased the feelings of 'job security' of the SA's, and it substantially affected the way they related to the operators." (Lawler, Hackman and Kaufman, 1973, pp.60-61.)

Any positive motivational changes in the operators may, therefore, have been counteracted by the subsequent behaviour of the SA's. The authors considered the benefit which may have been gained by involving the SA's in the redesign process from the start, and admit that they had paid insufficient attention to how the SA's job would be affected.

The company, however, considered the project to have been a success, for four reasons:

1. cost reductions through shortened training time;
2. possibility of reducing the number of supervisors;
3. absenteeism and turnover fell during the study; and
4. productivity and work quality were unaffected.

This job design project, therefore, provides equivocal support for the expectancy theory of job design. The model appears to lack at least two fundamental aspects: a means of predicting how proposed job design changes are likely to affect employees' ratings of a job on the four core

dimensions, and a means of predicting similar effects on related jobs, particularly those of immediate supervisors.

The expectancy theory of job design of Lawler and Hackman incorporates only two of the three characteristics of Herzberg's theory of job design. Lawler and Hackman have adopted (with modification) a view of human nature based on Maslow's need hierarchy theory; they have developed an expectancy theory of work motivation to explain how these needs may be satisfied in the presence of certain job characteristics, leading to higher performance and employee satisfaction; what their theory lacks is a technique for analysing an existing work situation and implementing the desirable job design changes. The strategy adopted in the 1973 project seems to have been very loosely based on that advocated by Herzberg (1968). This lack of technique is clearly a weakness in the expectancy theory of job design.

A British researcher, Robert Cooper (now at the University of Lancaster), has arrived at a list similar to that of Hackman and Lawler, of "... characteristics of industrial tasks which serve to arouse and/or satisfy the intrinsic motives." (Cooper, 1973b, p.389.) He suggests that intrinsic motivation is enhanced by four job characteristics:

- variety
- discretion
- contribution
- goal characteristics (Cooper, 1972, 1973a, 1974.)

The first three (variety, discretion and contribution) correspond closely with three of the characteristics suggested by Hackman and Lawler (variety, autonomy and task identity). Cooper does not treat

feedback, the fourth "core dimension", as a separate factor, but as a characteristic which can "shape up" employee perceptions of goal characteristics. Cooper argues that goals have two main properties - clarity and difficulty. Performance, therefore, is said to depend on goal structure, i.e. the clarity and attainability of the goal. Clarity of goal expression is likely to produce better performance than a goal stated in vague terms. Tasks which are of medium attainability (i.e. not too hard and not too easy) are likely to be the most motivating. Thus goals which are stated in unambiguous terms and which are fairly difficult to achieve will tend to lead to higher performance than goals which are not clearly defined and which are either easy or very hard to achieve. Cooper argues that maximum motivation will be aroused when all four characteristics are amply represented in a job, variety being the least important. (Cooper, 1973a.)

Cooper is not an expectancy theorist, but his approach is clearly similar to that of Hackman and Lawler. In comparing the two approaches, confusion may be introduced by considering Cooper's goal characteristics in expectancy theory terms. Goal clarity relates to "Performance" in the expectancy formula, i.e. what performance is required? Goal difficulty or attainability is analagous to the Effort → Performance probability, i.e. will a given amount of effort lead to success? In Cooper's terms, goal clarity and goal difficulty are objective characteristics of a particular job, whereas in the expectancy theory of Hackman and Lawler they are part of the individual's subjective assessment of his job. Variety, discretion and contribution (or variety, autonomy and task identity) are conceivably measurable in objective terms. The "objective" ratings which Hackman and Lawler

(1971) made of the jobs which they examined correlated highly on these three characteristics with the workers' "subjective" ratings. It is difficult, however, to see how the characteristics of goal clarity and goal difficulty could be objectively measured. The individual differences which one would expect to find in perceptions of these characteristics in a particular job would suggest that it may be more fruitful to view these not as objective job characteristics, but as characteristics of the individuals with which one is dealing. It is this latter approach which Hackman and Lawler have adopted.

Cooper gives little indication of how the job characteristics he has suggested can be operationalised, and he makes no recommendations concerning how to redesign jobs to incorporate these particular characteristics. He has been more concerned with developing a theoretical framework for use in further study of work motivation. Cooper's theory fits uncomfortably into the expectancy model, and it is argued here that the formulation of Hackman and Lawler is preferable.

Expectancy Theory : Criticism

Some criticism of the expectancy theory of job design has been mentioned above. Criticism of expectancy theory itself will be dealt with in this section. Expectancy theory has tended (slowly) to replace two factor theory in research concerned with work motivation. It is still undergoing a process of development at both theoretical and practical levels. There is still, for example, debate concerning the conceptualisation of the theory and of the terms which comprise it (valence, instrumentality, expectancy), and a number of difficulties arise over the operationalisation of these terms, regardless of how

they are defined: how are the components to be measured, which components are to be measured, should measures of role perceptions be included, how should intrinsic and extrinsic outcomes be differentiated, which performance measures are relevant, how can causality be assessed, how are extraneous variables to be controlled.

The term valence, for example, is sometimes used to mean experienced satisfaction (value) and not anticipated satisfaction (valence) as Vroom originally suggested. Such inconsistency is clearly unsatisfactory. Miner and Dachler (1973) claim that, overall, support for the theory is weak and contradictory with different studies indicating support for different components of the model. This state of affairs is neatly summarised by Locke (1975) who states that:

".... there are no consistent findings regarding which components are the best predictors of performance. Sometimes V works best. Sometimes I works best. More often E works best. The total V - I - E formula may predict performance better than any component by itself, or it may not. An additive model may work better than a multiplicative one, or there may be no difference. There have been no convincing explanations offered as to why whatever does work works, or why whatever does not work does not."
(Locke, 1975, p.458.)

Having examined a much larger sample of expectancy theory research than has been examined here, Miner and Dachler, and Locke, have noted that correlations between VIE constructs and objective performance in real life settings are generally low. In a recent comprehensive critique of expectancy theory, Locke (1975) deals with seven problem areas, some of which may contribute to the unsatisfactory results which the theory has produced.

1. Expectancy theory as psychological hedonism.

The hedonistic hypothesis states that humans strive for the

maximisation of pleasure, or the minimisation of pain. Writing in 1861, J.S. Mill stated the utilitarian hypothesis in similar terms:

"The utilitarian doctrine is, that happiness is desirable, and the only thing desirable as an end; (....) the sole evidence it is possible to produce that anything is desirable is that people do actually desire it." (Mill, 1962, p.288.)

This argument, however, is circular if it is merely assumed that when a person performs an act he is motivated by the pleasure which he will obtain from it; that is, because a person actually wanted to do this and not that, this "proves" that he was motivated by pleasure to do the former. A critique of hedonism applies to expectancy theory in so far as it makes similar assumptions. Pleasure, Locke points out, is not the sole basis for motivational preference. This may be seen in the existence of alcohol and drug addiction, neurosis, suicide, and of people who consciously renounce pleasure such as monks and nuns. Pleasure to the ascetic is not the same as pleasure to the non-ascetic.

This criticism does not apply to Lawler and his colleagues. Lawler cites evidence for a two step hierarchy of innate human needs ("pleasure" is not one of them) and his expectancy theory attempts to explain people's behaviour in the satisfaction of these needs. The theory only assumes that people's behaviour is goal directed and does not assume that any particular goal or need (such as pleasure) will be pursued or satisfied in a particular way. Behaviour is, therefore, largely determined by the individual's attitudes and beliefs concerning his various needs and the means available to satisfy them.

2. Individual differences in time-span.

There are enormous individual differences in ability to consider

outcomes and consequences at points in the future. Expectancy theory tends not to take account of this, apparently on the assumption that in this respect all individuals are alike.

3. Individual differences in cognitive load capacity.

There are also significant individual differences in mental capacity (cognitive load capacity) and differences in knowledge; individuals vary widely, therefore, in the number and types of actions which are considered when making decisions. This involves differences in what people see as important, and differences in persistence and self-esteem. Expectancy theory again ignores this problem, assuming that individuals behave alike when searching for consequences, terminating their search and integrating the information obtained:

"This assumption is exemplified in the typical research study in which the experimenter defines for the individual the precise outcomes and behaviors he is to consider when forecasting his actions, and even makes the subsequent V - I - E calculations for the subject - calculations which he would not make consciously, and may not actually make at all." (Locke, 1975, p.463.)

4. Subconscious motivation.

Individuals are not always conscious of their motives, premises, values, expectancies and the like. It is not, therefore, justified to assume that the individual consciously calculates the expected pleasure and/or pain associated with various outcomes. Individuals again differ in the extent to which they are aware of the content and processes of their minds.

5. Impulsive, expressive, neurotic and habitual behaviour.

A number of actions can be described as non-instrumental, performed without calculation and having a zero projected time span. Expectancy theory fails to take account of these.

6. The ratio scale problem.

This was raised by Hackman and Porter (1968), as mentioned above. Locke states that:

".... there is as yet no known method of measuring values or valences on a ratio scale (or even a true interval scale). Thus the form of the theory assumes the existence of measurements which do not exist."
(Locke, 1975, p.464.)

This is a more extreme view than that of Hackman and Porter who clearly felt that this was not a serious problem at all. Until the use of rating scales in measuring expectancies and valences can be replaced by a method which generates results with ratio or interval scaling, this criticism will remain valid.

7. The infinite regress problem.

The valence of a particular outcome equals the sum of the products of the valences of all other outcomes to which that outcome leads and the instrumentality of that outcome in producing these other outcomes i.e. $\sum(P \rightarrow O) (V)$. Locke continues:

"Thus, (theoretically) each particular valence is explained on the basis of other valences. Taken literally, this leads to an infinite regress, since each valence would have to be calculated by associating it with other valences and so on ad infinitum."
(Locke, 1975, pp.464-465.)

Individuals would not, of course, deal with such calculations, and

neither could the theory. As we have noted, Lawler has never intended that the theory should take account of all possible variables and their combinations for precisely the reason that man is incapable of doing this.

Expectancy theory and the expectancy theory of job design are still undergoing a process of development, and it is difficult to predict the directions which this will take. The aspects of the theory concerned solely with job design do not seem to advance the technique much beyond that of Herzberg, with particular reference to its implementation. The core dimensions given by Hackman and Lawler bear a close resemblance to Herzberg's motivator factors, and the techniques used to redesign jobs along the lines suggested are very similar. Expectancy theory also suggests how the effects of the job changes can be assessed, but some applications of job enrichment have used Herzberg's "job reaction survey", which differs in content (being directed at job satisfaction rather than task ratings) but has a similar objective. The expectancy theory of job design does not appear, however, to have been adequately tested and further applications may lead to improvements in both theory and technique. In the meantime, the theory remains more interesting than its application.

3. WORK ORGANISATION

Introduction

At the beginning of this Chapter, two conceptually distinct approaches to the design of jobs were identified. The approaches which have been examined up to this point have taken as their basic unit of analysis the individual job. The approach to be examined in this section, on the other hand, treats the primary work group as its basic unit of analysis (e.g. see Trist, Higgin, Murray and Pollock, 1963, p.8). Job restructuring approaches do not adopt an explicit model of organisation structure and functioning but restrict their analysis to the individual worker and the tasks which, taken together, comprise his job. In taking the group as the basic unit of analysis, the work organisation approach requires a model which describes the group's relationship with the rest of the organisation; this approach requires a model of organisational functioning.

The work organisation approach conceptualises the organisation as an open socio-technical system, and the primary work group as a sub-system which also has open socio-technical system properties.

A further characteristic of job restructuring approaches to the design of jobs is that their development has taken place mainly in America. Austrian born Ludwig von Bertalanffy is attributed with the conception of "general system theory" (von Bertalanffy, 1950, 1968) but the development of a socio-technical system theory of organisation has taken place mainly in Britain. This work has been carried out by a number of industrial consultants, working at the Tavistock Institute of Human Relations in London, such as F.E. Emery, E. Trist, A.K. Rice, E.J. Miller and P.G. Herbst, and a number of others.

The Tavistock Institute was founded in 1947 as "an agency for psychologists with interdisciplinary inclinations to make available to industry the expertise they had accumulated on personnel and other problems in the war." (Rose, 1975, p.177.) Their theoretical framework has been developed through consultancy experience in a variety of enterprises - the Glacier Metal Company and the Durham Coal Mines in Britain, and the Ahmedabad Manufacturing and Calico Printing Company in India were among the first, and the literature concerning them is now widely known. Before examining the specific projects which have guided this development, some of the basic concepts of systems theory will be examined.

Systems Characteristics

The word "system" is in common everyday use in the English language; we talk about the solar system, traffic management systems, communications systems, waste disposal systems, and so on. Intuitively, the word "system" presents little or no problems of understanding, but it is inordinately difficult to define with rigour. On a superficial level, a system may be defined as something which functions by virtue of the interdependence of its component parts. While basically true, such a definition is of limited value since it can be seen to apply to practically anything - to a can opener, for example, or to the human body. The human body may clearly be described as a system, i.e. as an interdependent whole. Human visual perception, however, can also be described, and analysed, as a "system" in its own right. So might the digestive system, the autonomic nervous system, and any other "sub-system" of the whole body. We shall see below how groups of humans can also be described and analysed as systems.

The point is that what one defines as a system (or where one draws the system "boundaries") depends entirely upon what one wants to examine and why. The system boundaries are determined by the reasons for looking at that system in the first place.

Can openers and human bodies, while both capable of being regarded as systems, have fairly obvious fundamental qualitative differences. The most important difference (at least in systems theory terms) is that the human body interacts purposively with its environment, whereas the can opener does not. The human body takes into itself (imports) air, food, drink and a diversity of perceptual information; it transforms (converts) these imports into energy; it disposes of (exports) this as waste products and as selected manners of behaviour. The human body must carry out these import - conversion - export processes in order to survive. The can opener, of course, can do none of these things, nor does it have to. Its existence is not dependent upon transactions with its environment. The can opener is a "closed" system, unlike the human body which in common with all living things is an "open" system. All living systems are open systems in that they are dependent upon transactions with their environment in order to survive. Living systems at the biological level are also able to re-establish their internal states after a disturbance. The human body, for example, has built-in mechanisms which maintain the body's core temperature at around 96.4 degrees fahrenheit, within certain extremes of ambient temperature. This general property of "self-regulation", or "homeostasis" as it is sometimes called, is said to apply to all open systems.

The results which closed systems are capable of producing are wholly determined by the initial configuration of the system. A

chemical reaction is a closed system, and the final result is dependent upon the concentration and quantity of the chemicals used to begin with. Open systems, on the other hand, are capable of achieving a particular end result from a variety of initial configurations. Such behaviour is called "equifinal"; one irritating example of equifinality lies in the capability of some common garden weeds to continually reappear no matter how badly damaged they have been by the spade.

To summarise, open systems have the following characteristics in common:

1. they are dependent upon matter - energy exchanges with their environment for survival;
2. they are self-regulating;
3. their behaviour shows equifinality.

Socio-technical system theorists have assumed that these characteristics apply to industrial organisations, as these can also be regarded as open systems. (For a more thorough introduction to systems theory, see von Bertalanffy, 1968, and Emery (ed.), 1969; these are perhaps the best and certainly the most easily available introductory texts on systems theory and Emery's readings include several that deal with human organisations from the systems point of view.)

Enterprises* as Open Socio-Technical Systems

An enterprise is comprised of human beings, therefore, it is a living system and may be conceptualised as an open system.

* The theorists whose work is examined here tend to use the term "enterprise" to refer to a company, and to use the term "organisation" to refer either to a company, or to "the patterning of activities" in an enterprise. (Miller and Rice, 1967, p.33.) The less ambiguous of these two terms, i.e. enterprise, will be used throughout this section.

Further support for this contention may be obtained by looking at how the enterprise maintains itself. It imports capital, materials, equipment, labour and information; it converts these into goods or services; it exports finished products or satisfied customers, dividends and waste materials. The activities of every enterprise can be described in terms of its import - conversion - export processes. This view of the enterprise is commonly referred to as the "organic analogy". Rice (1963), for example, states that:

"This book seeks to establish a series of concepts and a theory of organisation that treats enterprises as living organisms." (p.179.)

And in the Introduction to a later book, Miller and Rice (1967) write:

"Any enterprise may be seen as an open system which has characteristics in common with a biological organism." (p.3.)

Enterprises, therefore, also have the properties of self-regulation and equifinality. Emery and Trist (1960) argue that if this is so, it follows that:

".... such systems may spontaneously reorganise towards states of greater heterogeneity and complexity and that they achieve a 'steady state' at a level where they can still do work. Enterprises appear to possess at least these characteristics of 'open systems'. They grow by process of internal elaboration and manage to achieve a steady state while doing work, i.e. achieve a quasi-stationary equilibrium in which the enterprise as a whole remains constant, with a continuous throughput, despite a considerable range of external changes." (p.282 in Emery (ed.), 1969.)

Thus, unlike closed systems which maintain or move towards states of greater homogeneity, open systems tend to develop greater internal elaboration or heterogeneity through a continual rearrangement of their component parts. These processes can be readily identified in enterprises.

Eric Trist was originally responsible for the idea that an

enterprise may be conceptualised, not simply as an open system, but as an open socio-technical system. (See Trist and Bamforth, 1951.) The interdependence of social and technological aspects of organisation had become apparent during the work with the Durham coal mines (discussed below):

"Trist's concept of the socio-technical system arose from the consideration that any production system requires both a technological organisation - equipment and process layout - and a work organisation - relating those who carry out the necessary tasks to each other." (Rice, 1963, p.182.)

While the form of work organisation is constrained to some extent by the demands of the technology in use, it has its own independent, social and psychological properties. A third factor must also be taken into consideration - the economic environment of the enterprise. It is this economic dimension which provides a measure of overall system effectiveness. When optimum conditions are achieved for one of these dimensions, this will not necessarily produce optimum conditions for the system as a whole. The socio-technical system approach, therefore, relies on the "joint optimisation" of these three system characteristics, resulting in a less than optimum state for each separate dimension. (See Trist et al, 1963, p.7.)

Enterprises are purposive, goal-seeking entities, and at least for the kind of enterprise considered here the ultimate goal is survival. Rice considers it more useful, however, to discuss the objectives of an enterprise in terms of its "primary task", i.e., "... the task that it must perform to survive." (Rice, 1963, p.13.) The import - conversion - export process of the enterprise as a whole is its primary task, and this process relates the enterprise to its environment. There are four basic points to note in analysing the

primary task of an enterprise:

1. The constituent parts of an enterprise usually have their own discrete primary tasks to perform. These may conflict with each other, in the way that the objectives of marketing and production departments often seem to do.
2. An enterprise as a whole may have more than one primary task. Teaching hospitals have two primary tasks - treating patients and instructing medical students.
3. Where an enterprise has more than one primary task the question of task priority arises. Prison authorities must compromise between the primary tasks of confinement, punishment and rehabilitation. This is frequently a source of confusion and a rational solution may not be available.
4. The definition and performance of the primary task (or tasks) is constrained by environmental factors (political, legal, economic), and by the resources available to the enterprise (human, physical, scientific, technological). As these constraints are liable to change, the primary task must be periodically reappraised and, if necessary, redefined.

As enterprises increase their size they tend to differentiate internally into constituent sub-systems each with its own discrete primary task, and each carrying out its own import - conversion - export process. In a "simple" enterprise, one "operating system" may perform this entire process or the major part of it. In a "complex" organisation, on the other hand, there may be several operating systems:

"When a complex enterprise is differentiated into parts, the sub-systems that carry out the dominant import - conversion - export process, that is, perform the primary task of the enterprise, are the operating systems."
(Rice, 1963, p.18.)

There are three basic types of operating system:

- (a) import operating systems, concerned with the acquisition of materials;
- (b) conversion operating systems, concerned with the process of transforming imports into exports; and
- (c) export operating systems, concerned with disposing of the results of the import and conversion operating systems.

This raises the problem of identifying operating system boundaries. It was noted above that a system is assumed to have a boundary which separates it from its environment. Boundaries are created by discontinuities of some kind or another; Miller (1959) postulated that there are three bases, or types of discontinuity, which distinguish the boundaries of enterprise operating systems. These are technology, territory and time:

"Whenever forces towards differentiation operate upon a simple production system, it is one or more of these dimensions that will form the boundaries of the emergent sub-systems and will provide the basis for the internal solidarity of the groups associated with them."
(Miller, 1959, p.246.)

Rice argues further that when an enterprise has become differentiated into a number of operating systems, a concomitant differentiation of management is required to cope with the new arrangements:

".... a system external to the operating systems is required to control and service them. This is the managing system." (Rice, 1963, p.21.)

The managing system contains differentiated "maintenance" and "regulatory" activities*. The maintenance activities are those which "... produce and replenish the resources that produce operating activities." (Miller and Rice, 1967, p.6.) This includes purchase and repair of machinery, and personnel management services. Regulatory activities are those which "... relate operating activities to each other, maintenance activities to operating activities, and all internal activities of the enterprise (or unit) to its environment." (Miller and Rice, 1967, p.6.)

Miller and Rice make a further distinction between two types of regulatory activity - monitoring and boundary control activities. Monitoring activities are those concerned with checking that an operating system is performing its task satisfactorily. Boundary control functions are defined as follows:

"Regulatory activities that relate a system of activities to its environment occur at the boundary of the system and the environment and control the import and export transactions across it. Boundary regulation is therefore external to the operating activities of the system." (Miller and Rice, 1967, p.8.)

Maintenance and regulatory activities may also be described in import - conversion - export terms. Boundary control functions import information based on measurement or observation of the process being controlled; conversion consists of comparing this information with objectives or performance standards; exports consist of decisions to modify or stop the process (or not to modify or stop it), or to accept or reject the product.

* This is the terminology used in Miller and Rice, 1967; these were previously called "service" and "control" functions respectively, as indicated in the above quotation from Rice, 1963. See also Miller, 1959, p.243.

The boundary of an enterprise, and of its sub-systems, thus has two properties:

- (a) it represents a discontinuity in terms of either territory, technology or time, or some combination of these factors;
and
- (b) it implies the existence of a region of control.

Miller and Rice (1967) explain at length the difficulties which arise when system boundaries are either poorly defined or are defined inappropriately in terms of the two properties mentioned above. The main argument to which this exposition is leading is that the key function of management is boundary control. It is only at system boundaries that performance (that is, the difference between input and output) can be measured. It is the function of management, therefore, to define the boundaries of enterprise sub-systems, and to control transactions across these boundaries. This includes management of the relationships between the constituent systems of an enterprise, and the relationships between an enterprise and its environment. Rice refers to this latter function as "the primary task of leadership." (Rice, 1963, p.15.) In more specific terms, the tasks of the leader, or manager, are to:

- (a) manage relationships between the enterprise and its environment;
- (b) define the primary task(s);
- (c) review this definition and the constraints imposed upon it;
- (d) recruit resources;
- (e) control resource use;
- (f) assess results.

(See Rice, 1963, p.206.)

Rice recognised that some groups (such as the Durham miners and the Indian textile workers both discussed below) are capable of handling differentiated role systems without any formal management structure, and with only those decisions relating to the external environment being handled through management and unions. There comes a point, however, where the quantity of administrative and co-ordinating work that has to be done requires "... somebody who spends the majority of his or her time on control and co-ordination rather than on operation." (Rice, 1963, p.215.) While certain factors may postpone this differentiation, the implication is that it is inevitable:

"It can be inferred that, in any expanding or changing system there is an optimum or 'natural' stage for creating a new level of management. This is applicable equally to the initial transition from a simple system to a complex system and to the addition of a new level of an already complex hierarchical system."
(Miller, 1959, p.248.)

To summarise briefly up to this point, it has been argued that an enterprise may be differentiated into the following types of constituent sub-systems:

1. Operating Systems
 - 1.1 Import systems
 - 1.2 Conversion systems
 - 1.3 Export systems

2. The Managing System
 - 2.1 Maintenance activities
 - 2.2 Regulatory activities
 - 2.2.1 Monitoring functions
 - 2.2.2 Boundary control functions

The socio-technical system framework attempts to show how enterprises cope with variety in their environment by means of internal elaboration and differentiation, the purpose of which is to increase the system's independence of predictable environmental fluctuations. Along with social and technological factors, market pressures are thus regarded as a determinant of organisation structure. This type of response, however, may render the enterprise less able to cope with unpredictable environmental changes. Miller has noted two "resilience factors" which prevent or at least postpone the onset of internal differentiation; (a) the absence of permanent sub-groups within the enterprise, and (b) a high degree of interdependence between existing sub-systems. (Miller, 1959, p.248.) Rather than maintaining flexibility by internal restructuring which keeps these resilience factors in operation, an enterprise may attempt to directly influence its environment. Moving into new markets or changing existing ones are ways of doing this. The concept of resilience has been developed much further in the more recent work of Miller and Rice (1967), which is concerned primarily with forms of organisation which possess intrinsic flexibility in coping with environmental change. This work will be discussed shortly.

In any enterprise, the optimum form of organisation is that which is most conducive to satisfactory task performance. Miller and Rice, however, regard human needs as major constraints on task performance (see Miller and Rice, 1967, p. xi). They have developed a theory of human needs based on the work of W.R. Bion, a psychoanalyst from the Melanie Klein School at the Tavistock Clinic in London. Bion used his wartime experience with group selection methods and small therapy groups to produce a reformulation of

psychoanalytic concepts to explain group as well as individual behaviour. Bion hypothesised that groups operate on two levels simultaneously. On a conscious level, the "work group" meets to perform a specific task. For the group as a whole, work performs a function analagous to that of the individual ego in relating the group to reality and to its environment. On an unconscious level, the "basic group" operates unanimously on one of three assumptions:

".... to obtain security from one individual upon whom its members can depend, to preserve the group by attacking someone or by running away, or to reproduce itself." (Rice, 1963, p.182.)

These basic assumptions are also referred to, respectively, as dependence, fight-flight and pairing. The emotional associations which group members have concerning these assumptions may interfere with task performance. (Bucklow, 1966, gives a concise summary of Bion's influence on socio-technical system theory: other socio-technical system theorists, concerned more directly with the organisation of work, have adopted a view of human motivation which is not based on psychoanalytic concepts. This will be discussed below.)

Again following Bion, Rice also postulated the existence of "powerful social and psychological forces" which generate a capacity for co-operation in the performance of the primary task of the enterprise. (Rice, 1958, p.33.) Effective performance is regarded as an important source of satisfaction for those involved. Task performance must be organised in a particular manner, Rice argued, if such satisfaction is to be obtained. Rice had first developed a theoretical "ideal" work group organisation through his own work as a consultant in India. The socio-technical systems theory outlined

here, however, received a further major development explained in the later (1967) book by Miller and Rice, before Rice's death in 1969. It will have been noted that this book has been referred to frequently in the above passages, but one of its key arguments has not yet been touched upon. Through their accumulated experience in a variety of different enterprises, Miller and Rice came to regard their earlier prescriptions about work group formation as a special case of a general series of propositions. Successful formation of work groups was now seen to be contingent upon the rate of change in the environment of an enterprise. Thus the type of work group set-up appropriate to one particular enterprise in a given environment would not be suitable to another enterprise in a different environment.

The chronological sequence of this chapter is deliberately broken at this point in order to discuss these theoretical adjustments made by Miller and Rice. They are discussed because they are relevant to the theory of socio-technical systems, and because they are relevant to the thesis developed in the following chapters. Their arguments appear to have had no great effect upon either the objectives or the techniques of job design, however, and the continuity of the material discussed below is better maintained by looking at their arguments here.

Task and Sentient Boundaries

In "Systems of Organisation, the Control of Task and Sentient Boundaries", Miller and Rice (1967) are concerned principally with the design of organisational forms which simultaneously satisfy (a) the

needs of the enterprise to adapt continually to technological change, and (b) the needs of members of the enterprise for security and affiliation. Their socio-technical system perspective has not, therefore, altered; their main concern is with organisational design rather than with work group formation; generalisations about "ideal" work group formation give way to a contingency theory of organisational design.

Bion's distinction between the "work group" and the "basic group" has already been described. The "discovery" in the Hawthorne studies of the relative importance of "informal" as opposed to "formal" organisation has also been mentioned (p.49 above). Miller and Rice present a similar dichotomy of organisational groupings, between what they call task groups and sentient groups:

".... the task group being the group that comprises the individuals employed in an activity system, and the sentient group being the group to which individuals are prepared to commit themselves and on which they depend for emotional support." (Miller and Rice, 1967, p.253.)

The sentient group is also defined as one ".... that demands and receives loyalty from its members." (Miller and Rice, 1967, footnote, p.xiii.)

The Tavistock researchers through their earlier experiences in coal mining and textile manufacturing had come to regard the "right" organisation as that in which "the human groups required for task performance were always identical with those required to satisfy the social and psychological needs," (Miller and Rice, 1967, p.xiii.), i.e. in which the boundaries of task and sentient groups (or systems) coincided. Rice had always regarded resistance to change as "a natural phenomenon of all living organisms." (Rice, 1963, p.275.) and, therefore, as an undesirable property of an enterprise which has

to adjust to technological change. But where task and sentient groups are coincident, and group members invest their loyalty and commitment in their group, the process of change will be inhibited should that particular task grouping become inappropriate. The members will not wish to relinquish that membership. "To maintain adaptiveness", Miller and Rice argue, "the greatest sentience must remain vested in a group committed to change." (1967, p.260.)

Group sentience may be generated in a variety of ways and may have different meanings at different times. Sentience is strengthened (a) by the coincidence of task and sentient boundaries, (b) by a common belief in the group's objectives, and (c) by the members' belief in the complementary nature of their respective contributions. Sentience is vulnerable, on the other hand, (a) where task and sentient group boundaries are not coincident, (b) where group members are seen as complementary to the point of individual indispensability, and (c) where individual members are completely interchangeable and are thus dispensable.

In the coal mining and textile manufacturing projects discussed below, coincidence of task and sentient boundaries was contrived. The formation in both cases of internally led, composite autonomous primary work groups had the human advantages of compensating for job breakdown and loss of traditional craft skill, and the organisational advantages of increased production, higher quality and reduced costs. In some situations, however, task and sentient boundaries are naturally coincident. An example given by Miller and Rice is the small family business in which task and sentient boundaries coincide by definition. Certain tasks on the other hand preclude task and sentient group coincidence, particularly tasks that are temporary and transitional.

The flight crew of an aircraft is one example; the nature of the task and the stringent safety regulations render it prohibitive to continually roster the same plane, aircrew and cabin crew together. The flight crew is thus transient and temporary and is broken up at the end of each flight and reformed. Salesmen, whose task in obtaining customer orders is also transient, are another example of the natural impossibility of task and sentient group boundaries coinciding. The task of the Salesman crosses the boundary of the enterprise for which he is working and the task groups that he enters comprise himself and a member of another enterprise. There are obvious limits to the sentience which either member of this task group can invest in it. The loyalty and commitment of the Salesman must be directed mainly at his own enterprise (or perhaps at other Salesmen) and only partially towards his customers.

Miller and Rice adopt the argument that sentience is necessary, that the affiliation motive is innate:

"Social science studies in industry have emphasised the importance of the individual's affiliation to his primary work group and the deprivation and alienation created by technologies and forms of organisation that inhibit the building of such groups." (Miller and Rice, 1967, p.227.)

Contrived coincidence of task and sentient boundaries is one way of creating sentient groups, but this will be undesirable if it inhibits change. Miller and Rice, therefore, consider other ways of generating sentience. For the aircrew, "The significant sentient grouping within the organisation is then the pool of flying crew." (1967, p.206.) For Salesmen, on the other hand, there is often no such sentient group. Miller and Rice suggest appointing a supportive manager to whom representatives can turn for help or advice. Another possible solution which they suggest is the creation of small groups of Salesmen who

together handle sets of accounts normally divided between them. In suggesting these solutions, Miller and Rice note the lack of success which traditional measures for generating sentience have had, e.g. pension and housing schemes, staff parties, rallies, exhibitions, house magazines, sports clubs, profit-sharing and co-ownership schemes.

It is possible, Miller and Rice argue, to make a more general proposition regarding the generation of sentience in a manner that does not inhibit technological change. Task and sentient boundaries need not be coincident in order to satisfy either organisational or human needs; the alternative which they prescribe is the "project type organisation":

"The essential feature of a project type of organisation is that the group brought together to perform a particular task has to be disbanded as soon as the task is completed. This group has no further *raison d'etre* in terms of task performance." (Miller and Rice, 1967, p.129.)

A number of examples of project type organisation are given from the construction industry, research organisations, and air transport, and the objective of Miller and Rice is to present the project type organisation as generally applicable to any type of enterprise and to all manner of tasks. Thus:

".... a project type organisation which is appropriate and necessary for temporary and transitional activity systems, also provides the best basis for a general organisational theory." (Miller and Rice, 1967, p.251.)

If the task group is constantly broken up and its members redistributed in other similar task groups, sentience (i.e. commitment to the enterprise) must be generated in some other way. The appropriate sentient group for an aircrew, as discussed above, is the whole pool of flying crew. Research organisations similarly tend to form groups of scientific staff suitable to deal with the problems in hand. As

research questions are answered, these groups are dispersed and different groups are put together as novel problems come up. For any enterprise faced with technological change, Miller and Rice advocate this as the most appropriate form of organisation. This prescription is not restricted to white-collar staffs : Miller and Rice regard the project type organisation as equally appropriate for manual workers. The "pool", or "task-related sentient group" to which they belong must still possess a professional or quasi-professional basis:

"We envisage, for instance, a much greater use of the equivalent of the 'scientific' or 'professional' base, not only for specialists, but also for production workers who may have to return at frequent intervals to base for retraining in new skills before being deployed in a new task organisation." (Miller and Rice, 1967, p.246.)

While it is the contention of Miller and Rice that this prescription is universally applicable, there is an exception in one type of situation, and this is dependent upon the properties of the environment of a particular enterprise. The property of an enterprise's environment of overriding importance, as far as Miller and Rice are concerned, is technological change. The contrived coincidence of task and sentient boundaries is undesirable in enterprises which face such change, but this form of organisation may be appropriate in "relatively stable technologies" (Miller and Rice, 1967, p.257.), as a means of promoting sentience. Under these conditions, autonomous primary work groups (in which task and sentient boundaries coincide naturally) will be effective where:

1. the group is engaged on a "whole" task;
2. the group is able to regulate its own activities;
3. the group is of a size capable of self regulation and

- capable of providing satisfactory personal relationships;
4. the required range of skills is not as great as to induce internal differentiation in the group (and status differences do not inhibit internal mobility);
 5. the group is not unique and disaffected members can move to alternative groups. (See Miller and Rice, 1967, p.256.)

This brings us logically to the next section which deals with the development of the concept of the autonomous group from the work of the Tavistock researchers (including Rice) starting in the early 1950's.

Postscript on project type organisation:

A number of years ago, Plessey Radar Ltd. (part of Plessey Electronics) set up what they called "key task teams" in the display and data division. Each task team has a manager who draws up a "tender" for each task to be undertaken. The successful manager is then given the necessary finance, and proceeds to recruit his team members from a labour pool provided by the various functional departments. The teams are broken up and members return to their respective departments once the job is finished. This particular project type organisation produced cost savings of up to 20 per cent, and a reduction in labour turnover from 14 to 4 per cent in 2½ years. (Oates, 1970.)

Autonomous Group Working

The socio-technical system theory of organisation outlined above was developed initially through two major studies carried out by

workers from the Tavistock Institute; these studies were carried out, respectively, in the coal mines of Durham (Trist and Bamforth, 1951; Trist, Higgin, Murray and Pollock, 1963; Herbst, 1962), and in a textile mill in northwest India (Rice, 1953, 1958, 1963.)

The North West Durham Coal Mines

Deciding upon the title for the main report of these studies (Trist et al, 1963), may have given the authors some difficulty. The full title of the book is:

"Organizational Choice; capabilities of groups at the coal face under changing technologies; the loss, rediscovery and transformation of a work tradition."

The book does indeed deal with a number of issues, and the brief summary given here gives little indication of the wealth of detail given in the original. The main argument of the book, however, is that the form of work organisation introduced when mechanical coal-getting methods replaced traditional ways of working was not completely determined by the new technology. Other forms of work organisation could operate the new technology, and the enterprise, thus has "organisational choice".

Britain's coal mining industry was nationalised by the Labour Government in 1946. The anticipated improvements in productivity and management-worker relations did not materialise, and labour turnover and the incidence of stress illnesses amongst face workers remained high. Trist and Bamforth (1951) refer to medical investigators who noted "the epidemic incidence of psychosomatic disorders among miners working under mechanised conditions" (p.5.) Trist and Bamforth attributed these problems to the organisation of work associated with the partially mechanised longwall method of getting (i.e. obtaining)

coal. In order to investigate this hypothesis, an alternative form of work organisation, which had developed spontaneously in some pits, was studied. The research thus compared the operations of two kinds of work organisation, controlling as far as underground conditions would permit for neighbourhood equipment used and "type of men".

(Trist et al, 1963, p.xi.)

The first published report of this study (Trist and Bamforth, 1951), had described the dysfunctional social and psychological characteristics of the "conventional longwall" method of coal-getting. This system had been gradually replacing traditional "hand-got" methods since around the turn of the century. The fieldwork for the 1951 report was greatly reduced through the assistance of Bamforth who had been a miner himself for 18 years. Although the problems of the new system had been identified, the researchers were not yet prepared to offer solutions. The main report of the study covers the period January 1955 to March 1958, and Trist et al were by this time certain of what should be done to alleviate the malaise induced by the conventional longwall method.

Continuous methods of getting coal have now been developed, but the methods studied in the 'fifties were cyclical, the production cycle having three stages:

- (a) preparation, in which the coal is either cut by hand, (previously with a hand pick, now with pneumatic picks), or undercut and blown down into the space cleared;
- (b) getting, in which the coal is loaded into tubs or onto a conveyor for removal from the face to the surface;
- (c) advancing, in which the roof supports, gateway haulage roads and conveyor equipment are moved forward.

Mechanisation had gradually replaced "single place" working where one or at most two miners worked with picks at faces ("places") six to eleven yards long. These men worked in self-selecting groups ("marrow" groups) which shared a common paynote and worked the same place on the same or different shifts. Once cut, the coal was shovelled by hand into $1\frac{1}{2}$ ton tubs and removed on rail. Each miner performed a "composite work role", i.e. he was capable of carrying out all the necessary face tasks: "He is a 'complete miner' - the collier - who supervises himself and is the person directly responsible for production." (Trist et al, 1963, p.33.)

The traditional system, organised around the composite autonomous miner, had several advantages. The production tempo was slow but it was maintained throughout and across shifts. This avoided periodic overloading of winding capacity and ensured the constant occupation of services (such as haulage and flow of supplies). Very little organisation was required to maintain production because the seam as a whole became virtually self-regulating. Management was thus rudimentary, and the pit deputy's main responsibilities concerned the application of safety regulations, maintenance of supplies to the workmen, and shotfiring when required.

The length of face that could be worked at any one time was greatly increased by the use of belt conveyors. In North West Durham pits, straight "longwall" faces were generally 80 to 100 yards long (hence the name). The major economic advantage of the face conveyor is that the amount of stonework involved (in advancing the gateways) in relation to the extraction area is significantly reduced. The coal/stone ratio becomes more crucial to the economic viability of a pit with thinner seams. The extension in the length of the coal face

created a novel organisation of work at the face. The first longwalls were simply extensions of single place working, preparation and getting being performed together for the first two shifts and advancing in the third. These were referred to as "hewing longwalls". The cycle was separated into its three discrete stages with the introduction of the electrical coal cutter. The "cutting longwall" was the most widespread longwall technology in Britain at the time of the Tavistock study. The three stages - preparation, getting and advancing - were each performed by a separate task group each working on a separate shift. The cyclical nature of the process was now dominant with coal being removed on only one of the three shifts. Each shift now had to complete its stage of the process before the next shift could begin work. Balancing the work of the three shifts now became a major problem.

The most significant change to the organisation of facework introduced with the longwall method was the abolition of the composite autonomous workman. Trist et al (1963) compare this conventional longwall method with the mass production methods of industry in general (p.xii). It involved maximum job breakdown and work role specialisation. Workers were allocated to one task on one shift with no opportunity for rotation and thus no means of enhancing their skills. The marrow relationship was continued to some extent in the new "single task" groups which now covered only one stage of the cycle. Lacking those two characteristics - the composite workman and the marrow group - the new work organisation was inappropriate for the underground situation. The miner has two types of task to contend with simultaneously; the activities of the production cycle, and the "background" task of coping with interference from underground

working conditions. The production skills, if physically demanding, are not complex and may all be learned by one person within a comparatively short period. Skill in dealing with the exigencies of work underground is of a higher order and is only developed by experience over a number of years. The underground work system should ideally ensure that the relevant experience is obtained in order to develop the faceworker's capabilities to the fullest extent. The conventional longwall system, Trist et al (1963) argue, restricts the faceworker in this respect.

The nature of the task breakdown and resulting payment systems in the conventional longwall system created status differences absent in traditional marrow groups. Cuttermen, who work the entire length of a face using a large and powerful piece of machinery, formed a "face aristocracy". The fillers, working on their own shovelling coal in a confined space, had the lowest status. The pay of each task group was now calculated on a different basis and each group conducted its own negotiations with management. The goal of cycle performance was displaced by the primary concern of each task group to improve its own relative position.

Unlike the traditional method, the conventional longwall system was not self-regulating but thrust the responsibility for cycle co-ordination into the hands of management. Because self-regulation was now structurally impossible, management had to rely on price negotiation to control the cycle. This became a key characteristic of the conventional longwall method, and "management through the wages system" developed into a highly complex bargaining process. Not only main tasks but sub-tasks and ancillary tasks became the subject of separate agreements. No common denominator could be used to establish

rates for the different task groups and several criteria had to be used (e.g. tonnage, yardage, cubic measure, number of operations completed). Task groups would typically seek special payment for work not carried out by groups preceding them in the cycle. So each shift had a vested interest in the previous shift not completing its task. The negotiating procedures consumed vast amounts of otherwise productive time and energy.

Some pits, however, had developed a form of "shortwall" work organisation with characteristics approximating more closely to those of the single place tradition. These "composite shortwalls" were worked by multi-skilled groups, each on a common paynote, who were responsible for the whole coal getting cycle on any one shift. In one of the Durham pits, roof conditions had necessitated the return to shortwalls as long faces had become impossible to support. Increasing costs eventually forced the management to consider a return to longwall working. The men, however, resisted this suggestion partly on grounds of safety, but also because they did not wish to give up the "composite" form of work organisation they had developed and return to a system which tied them to particular tasks and shifts, i.e. the conventional longwall. Instead, an agreement was negotiated which attempted to preserve the social and psychological advantages of composite groups while solving the economic problems which necessitated working longer faces. Trist et al (1963) refer to this as the "Manley innovation" (p.73.) and the result was self-selected cycle groups of 41 men who allocated themselves to tasks and to shifts and who received payment on a common note. (This payment system removed the need for continual rate negotiations.) This "Manley innovation" is more commonly referred to as the composite

longwall method.

The new composite longwall system had four main characteristics:

1. Task continuity was maintained. Each shift took up the cycle at the point at which it was left by the preceding shift. When their main task was complete, they automatically went on to the next stage of the cycle. This feature was vital to the operation of the composite work method.
2. The system required multi-skilled miners. Each man did not have to possess all the necessary skills as long as the group as a whole was able to deploy the resources required on each shift. Groups were, therefore, composite in terms of the range of skills contained within the group, and autonomous in operating their own task and shift rotation.
3. Work groups were self-selecting and resembled the traditional marrow groups.
4. The groups were each paid on a common paynote since all members were regarded as making equivalent contributions.

These "Manley" groups were essentially leaderless. Their "team captains" acted as representatives, not as executives. The workers themselves arranged task and shift rotation which allowed them to maintain their skills and gave them constant reminder of the conditions under which other shifts had to work, and of the consequences of sub-standard work. Herbst (1962) provides a graphic description of the typical face conditions under composite working:

"The astonishing change in the physical appearance of the work-place, which would be the first thing to impress itself on a visitor, has come to be recognised as almost a hallmark of a composite work group. (...) Although the men were not responsible for equipment in the gates, they would use their lunch break to check and, if necessary, do repairs to the mothergate belt which leads to the face, anticipating and preventing possible disturbance of their work. No man was ever out of a job. If he finished hewing or pulling before others he would join and help them, or go on to some other job which was to follow. If work was stopped owing to breakdowns in the transport system on which the group was dependent for its supply of tubs, the men would go on to do maintenance work." (Herbst 1962, p.6.)

Although the task and shift rotation systems diverged, as they developed, from the original union-management agreement, management never considered it necessary to investigate the changes which took place, or to put a stop to them. These systems continued to operate to the mutual satisfaction of both parties.

Figures 2.7 and 2.8 illustrate briefly the comparison between a composite and a conventional longwall in terms of their respective effects on faceworker behaviour and production.

The effect of the composite longwall method on management was also marked. Trist et al (1963) state that "There was no greater contrast between the conventional and composite faces than in their management." (p.128.) The composite organisation, like the traditional single place working, was self-regulating and the deputies were freed from their responsibility under the conventional system of "...'propping up' a cycle always to some extent falling down on itself...." (p.129.) Management and workers in the composite system were not involved in the interminable wage rate negotiations of the conventional system, as mentioned above.

For the researchers, one of the most significant findings of

Effect on	Composite Longwall	Conventional Longwall
1. Approach to work.	Effects of activities on subsequent shifts were anticipated; higher standard of workmanship; much tidier workplace.	Careless - no regard for the effects of task performance on other groups; limited perspective.
2. Non-cycle activity (ie ancillary work arising from disorganisation or stoppages).	0.5 per cent.	32 per cent of the activities of task groups; this is an average figure which in practice was highly variable; most of this was "made work", ie created by other groups not completing their tasks.
3. Inter-group relations.	Single marrow group with common goal; this type of problem did not therefore arise.	Competitive, collusive, suspicious and unresponsive; there was collusion over "made work" to boost earnings.
4. Face experience.	The rotation systems gave a varied experience in all the main tasks.	Each man was assigned to one task only.
5. Absenteeism.	8.2 per cent of possible man-shifts; stress created by bad working conditions was shared across the group.	20.0 per cent; individuals experiencing bad working conditions simply had to put up with them on their own.

Figure 2.7: Effects of the composite and conventional longwall mining methods on faceworker behaviour (based on Trist et al, 1963).

Effect on	Composite Longwall	Conventional Longwall
1. Cycle progress	Usually to schedule, and often ahead of itself because each shift group would go on to the next stage of the cycle as soon as their own was complete; "task continuity" was thus maintained. No reinforcements were ever required to help keep to schedule.	Erratic, due to time lost on ancillary work; the cycle could never be in advance because subsequent stages were the province of other groups. An average reinforcement rate of 6% a week was required.
2. Regularity of production.	The group observed ran for 65 weeks without losing a cut.	The group observed ran for a maximum of 12 weeks without losing a cut.
3. Level of productivity.	Output per man-shift (for faceworkers) was 5.3 tons. Making full allowance for the interference of working conditions, production was 95 per cent of potential maximum.	Output per man-shift (for faceworkers) was 3.5 tons. Making full allowance for the interference of working conditions, production was 78 per cent of potential maximum.

Figure 2.8: Effects of the composite and conventional longwall mining methods on production
(based on Trist et al, 1963).

the study (regarding composite work organisation) was:

".... the ability of quite large primary work groups of 40-50 members to act as self-regulating, self-developing social organisms able to maintain themselves in a steady state of high productivity throughout the entire period of their 'missions'." (Trist et al, 1963, p.xiii.)

The "mission" in this case is the management of the three shift work cycle, and is another term for "primary task".

The central thesis of the Durham coal mines . research is that the work organisation originally associated with longwall technology was not inevitable. That is, "organisational choice" exists because the social system is not wholly determined by the technical system. The conclusions of this work have not passed without criticism, which will be mentioned in a later section; they gave strong support, however, to the main argument of job design theorists in general, that job content is not wholly dictated by technology.

The Ahmedabad Textile Mills, India

The work in Durham ran almost concurrently with the mutually supportive work of A.K. Rice (also from the Tavistock Institute) at a textile mill in north west India, at Ahmedabad. The problems facing these textile manufacturers and the coal mines and the solutions that were developed, show a striking similarity.

The Chairman of the Ahmedabad Manufacturing and Calico Printing Company Limited (Calico Mills for short) visited the Tavistock Institute in 1952. As a result, Rice (accompanied on his second visit by G.M. Stalker) went to India in 1953 to act as a consultant to the company on a broad range of management problems. The problems created by increasing mechanisation in an agricultural/

rural economy appeared to be the most pressing. As in British coal mining, mechanisation of textile manufacturing had destroyed the traditional craft of the weaver by introducing mass production methods.

By March 1953, the shed at the Mill which Rice was to study (the experimental shed) contained 224 automatic looms for the manufacture of a range of cloths. The work was organised on standard British and American lines with different workers performing discrete operations. While the working conditions were considered to be very good, productivity was much lower than had been expected. The 29 workers who manned the looms in the shed were allocated to tasks in the following manner:

- 8 weavers, who operated the machines, investigated stoppages, mended broken warp threads and fixed minor entanglements;
- 3 smash-hands, ("weavers in training") who dealt with major breakdowns and entanglements;
- 5 battery fillers, who maintained the supply of fresh bobbins;
- 2 gaters, who replaced completed "beams" of cloth with new warps;
- 2 cloth carriers, who cut and removed the finished cloth;
- 2 jobbers, plus 2 assistant jobbers, who were responsible for general loom maintenance and adjustment;
- 1 oiler, who serviced the looms with an oil can;
- 1 feeler-motion fitter, who serviced the device that ejected empty bobbins;
- 1 humidification fitter, who maintained the humidifier plant;
- 1 bobbin-carrier, who removed empty bobbins and returned them to the spinning department;
- 1 sweeper, who removed dust and fluff from the shed.

This extreme task breakdown presented a number of problems. The production process was continuous (rather than cyclic, as coal getting was) and the various tasks were interdependent. The roles that had been allocated, however, did not create any stable internal work groups but formed instead an aggregate of individuals who operated virtually independently of each other. There was confusion concerning status and lines of authority; difficulties arose, for example, when smash-hands were required by more than one weaver at the same time. This confusion was compounded by the variability in allocations of roles to the looms. On average, the following assistance was available to each weaver:

$\frac{1}{4}$ of a jobber pair,

$\frac{5}{8}$ of a battery filler,

$\frac{3}{8}$ of a smash-hand,

and so on. Rice concluded:

"The overall picture is of a confused pattern of relationships among an aggregate of individuals for whom no stable internal group structure could be discerned." (Rice, 1958, p.57.)

The only way in which groups could be given "whole" tasks was if they could carry out all the weaving, gating and maintenance activities. The possibility of allocating a group of workers to a group of looms was thus considered. The optimum size of these groups would differ depending upon the type of cloth being made as this put different demands on the machinery. For a block of 64 looms, optimum group size was calculated to be between 6 and 8 workers (8 for coarse cloth, 6 for fine). The internal work group structure was felt to have three "natural" grades : a group leader, a fully experienced weaver or gater, and those on less skilled jobs

(battery filling, sweeping, oiling, carrying). This structure was to allow for task rotation, and all members were now to be paid on a piece rate basis.

The original plan was to set up an experiment with one group of workers on one group of 64 looms on one shift. A number of discussions with Shift Supervisors and workers were planned as a necessary introduction to the changes. To begin this programme, the Works Manager started discussion of the proposals with the Supervisors one evening. The following morning, quite unexpectedly, the workers had spontaneously organised two self-selected experimental groups on the first shift. The following day, another two similar groups were organised by the other shift working the same two blocks of looms. Each of these groups comprised seven workers, four in a weaving sub-group and three in a gating and maintenance sub-group. These groups claimed to be able to cope with all ancillary services. The management felt that they had lost control of the situation, but despite their misgivings they decided to allow the groups to continue to function.

The basic experimental period lasted for 59 working days, from 30 March to 7 June 1953. During the first few days, weavers could apparently be seen running to their looms, and gaters trotted around the shed carrying beams weighing over 200 lbs on their shoulders. With an outside temperature of over 100 degrees fahrenheit, and an artificially maintained plant humidity of 85 per cent, this pace was clearly too fast to endure. There was an immediate increase in efficiency with the experimental groups, but the percentage of damage increased and loom maintenance was neglected. Performance was quickly restored to above normal levels

after the Top Supervisor had taken charge of one group for three days to investigate the problems. Once the experiment was running satisfactorily, discussion began over the possibility of keeping the looms running during meal breaks. The looms were soon left running, over lunch, until a yarn broke stopping a machine automatically.

After 37 days, the requests of the workers in the rest of the shed to reorganise themselves in experimental-type groups were granted. The overall results of the reorganisation indicated two major improvements.

- (a) Substantial increases in efficiency were achieved. Efficiency was defined as the number of "picks" or weft threads inserted in any shift as a percentage of the number of picks that would have been inserted under continuous running of the looms; and
- (b) Decreases in damage also occurred. Damage was defined as the percentage of cloth of sub-standard quality.

Language difficulties and the unprecedented speed with which the reorganisation was implemented prevented Rice from asking the workers why they had spontaneously accepted the new work organisation. There had been no overt complaints about the conventional system, and Rice concludes that:

"It seems reasonable to infer that their acceptance of 'a group of workers for a group of looms' was the result of an intuitive recognition that it provided a means of satisfying needs of which they had been, and probably still were, largely unaware." (Rice, 1958, p.81.)

The characteristics and advantages of autonomous work groups have been investigated further by Trist, Rice and a number of other researchers. These will be examined in detail following a brief introduction to the work of Louis E. Davis. The claim was made above

that socio-technical systems theory is a British product. Davis, now Professor of Organisational Sciences, Graduate School of Management, University of California at Los Angeles, has made a prodigious contribution to the field of job design, and his work has been influenced greatly by that of the Tavistock Institute. He has more recently worked with the Tavistock Institute on various projects and may now be regarded as a "member" of that "school". His earlier work, however, was not based on systems theory although some of his ideas developed along similar lines. Davis' work up to 1966 is another section of the job design literature which (like part of the work of Miller and Rice) does not fit comfortably into a chronological exposition. In 1966, Davis (1966) published a review article summarising some of his own research and that of Trist et al (1963) and Rice (1958, 1963), concluding that the combined results of these studies supported the Tavistock model of "responsible autonomous job behavior". This digression into Davis' previous work is but a short one, and his subsequent contributions are not again separated from the main body of the text.

Louis E. Davis

Davis' initial approach to job design was a job restructuring one, what he called a "job-centred" approach (Davis, 1957a, p.306). His concern was with the specification of the content of individual jobs:

".... the job design process can be divided into three activities: (a) the specification of the content of individual tasks, (b) the specification of the method of performing each task, and (c) the combination of individual tasks into specific jobs." (Davis, Canter and Hoffman, 1955, p.65 in Davis and Taylor 1972; and Davis 1957b, p.171 in Yukl and Wexley, 1971.)

A second feature of Davis' approach has been his objective of formulating a set of systematic guiding principles for those who have to design jobs. The main criterion for the formulation of these principles is the total economic cost measure which takes into consideration "... relevant long-term changes in the form of money, time, growth and psychological, social and cultural stress costs." (Davis and Canter, 1956, p.281; Davis, 1957a, p.307.) Job design principles would thus be directed at minimising total economic cost, and not just at minimising immediate or direct costs. The concept is similar to that of "joint optimisation" of the social and technological systems, but Davis recognised the problems involved in making his total economic cost measure operational.

Davis' growing affinity with the socio-technical systems approach is illustrated in his definitions of the concept of job design; thus in a 1957 paper he gives the following definition:

"Job design may be conceived as the organisation of the content of a job to satisfy the technical-organisational requirements of the work to be accomplished and the human requirements of the person performing the work."
(Davis, 1957a, p.305.)

Here again he comes close to expressing the concept of joint optimisation; but although job design is seen as taking place within a "three-dimensional framework of organisational, technical and personal factors" (Davis, 1957a, p.306.), the actual technique adopted is a job-centred or job restructuring one.

Davis drew up a research programme to discover the set of guiding principles for job designers. This was to consist of an impressive multivariate analysis, through controlled experiment, investigating the relationships between job content factors and productivity, quality, costs, and job satisfaction. The principles thus deduced could then be used to design job content and to predict

performance:

"The immediate steps to be undertaken in a study of job design are those concerned with the identification of variables and their classification into criterion, dependent and independent variables; with the development of hypotheses; and with the identification of the effect of job designs on productivity, costs, human resource use, etc." (Davis 1957 a, p. 308.)

Amongst the first steps actually undertaken was a study conducted by one of Davis' students which he cites as "one of the first controlled experiments on job design." (Davis, 1957b, p.174. in Yukl and Wexley, 1971.) This was essentially a job enlargement project which entailed changing the line assembly of a hospital appliance to an individual assembly (see p.57 above). The "group job design" which was one phase of this experiment, and which was unsuccessful, is misleadingly named; the only change made to the assembly line was to eliminate conveyor pacing and to allow the female assemblers to work at their own speed.

An example of vertical job enlargement is described in Davis and Werling (1960), another attempt to correlate job factors and performance. The authors concluded that:

"Job enlargement that increases skills of jobs, adds control over work content, rate and quality, adds completion activities, and permits the development of wide job knowledge seems to yield reductions in operating costs, and increased quality and quantity of output." (Davis and Werling, 1960, p.130.)

These conclusions are more in line with those of Herzberg and Lawler than with Trist and Rice.

Davis also studied supervisory job enlargement (Davis and Valfer, 1965 and 1966). These attempts to study "job design variables of first-line supervisory positions" (Davis and Valfer, 1965, p.171) illustrate the confusion created by trying to redesign jobs at one hierarchical level in isolation from related jobs on

adjacent levels. The supervisory job design prescriptions appear to conflict with the conclusions of Davis' other 1966 paper which supports the socio-technical systems theory model of "responsible autonomy"; groups of workers (e.g. miners and weavers) take collective responsibility for the activities which they carry out, operating without supervision.

Davis' active collaboration with the Tavistock Institute began in 1966: see Emery (1966), and Davis and Engelstad (1966). From this point on he will be treated as belonging to that school of thought - a fully fledged socio-technical systems theorist.

Properties and Advantages of Autonomous Groups

Rice (drawing again from the work of Bion) made two fundamental assumptions about individual behaviour at work:

- (1) "The performance of the primary task is supported by powerful social and psychological forces which ensure that a considerable capacity for cooperation is evoked among the members of the organisation created to perform it." and
- (2) "... the effective performance of a primary task can provide an important source of satisfaction for those engaged upon it."

(Rice, 1958, p.33.)

The problem lies in realising this latent capacity for co-operation. If work is to have this effect, Rice argued, it must be meaningful, i.e. it must be a task which those who carry it out can comprehend and to which they can contribute. It must be a task for which they

can take responsibility, and contributions must be necessary and valued. Very difficult and very easy tasks evoke anxiety and stress either through poor performance or wastage of talent. Following Argyris, Rice (1963, p.252) claims that tasks without responsibility force individuals into dependent child-like roles, frustrating those with aspirations to maturity.

Rice postulated that satisfaction from primary task performance would result only if:

- (a) tasks are organised such that the individual has -
 - (i) a "whole" task to perform;
 - (ii) control over his activities; and
 - (iii) satisfactory relationships with those performing related tasks;

and also if

- (b) work groups are organised according to the following principles -
 - (i) groups should ideally have from six to twelve members, the optimum being eight;
 - (ii) the range of skills required should be such that group members can comprehend all of them;
 - (iii) prestige and status differentials should be small; and
 - (iv) groups should not be unique and disaffected members should be able to transfer to similar groups.

(See Rice, 1958, pp.34-35 and 37-39.)

(Rice, 1958, in fact argues that skill levels should be hierarchically structured, but providing opportunities for change in status and rotation between comparable skills.)

The original tasks in the Calico Mills loom shed did not meet these criteria, but Rice argues that the reorganisation of tasks in the shed fulfilled these requirements. As noted above, Rice took the workers' spontaneous acceptance of and subsequent satisfaction with the new work organisation as "proof" of the validity of these initial assumptions. The characteristics of the groups operating the composite longwall method of coal getting were similar to those of the reorganised weaving groups. The main difference was probably group size; the weaving groups had seven members, but Trist et al (1963) described self-regulating composite groups with over 40 members. These comparatively large groups of multi-skilled face workers ensured continuity of the coal getting cycle without supervision. The group determined the deployment of its members and was paid on a common paynote. (The relative wage differential within the experimental groups at Calico Mills was 3.8; using the new entrant rate as the base, the relative differential was 6.1: Rice, 1958, p.69.)

A central argument of the work organisation approach to job design, therefore, is that group work is more likely to provide meaningful work, to develop responsibility and to satisfy human needs in general than is work which is allocated to separately supervised individuals. Emery (1959) summarises this argument thus:

"If the individual's tasks are genuinely interdependent with the group task, then it is possible for the individual to be meaningfully related to his personal activity through his group task. A group task with its greater size and complexity is more likely to provide structural conditions conducive to goal setting and striving. If it has a measure of autonomy and a wide sharing of the skills needed for its task, a group is also able to provide a degree of continuity in performance that is unlikely to be achieved by individuals under the control of a supervisor." (Emery, 1959, p.185 in Davis and Taylor, 1972.)

In what appears to have been a collective effort, various Tavistock researchers (other than Miller and Rice) have formulated a set of task and work group organisation hypotheses. These are a more detailed extension of the principles for task and group organisation which Rice (1958) outlined. The hypotheses arise, first, from consideration of the types of human needs relevant to behaviour at work, such as:

- (a) the need for affiliation and supportive social contact;
- (b) the need for achieving and maintaining a favourable self-concept;
- (c) the need for influence and control over one's environment;
- (d) the need for satisfying curiosity;
- (e) the need for social and economic security.

(van Beinum, 1966, p.62.)

Miller and Rice deal only with the affiliation and security needs.

Given these needs, the major psychological requirements pertaining to job content, therefore, are -

1. the need for job content to be reasonably demanding (other than in merely physical terms) and to provide variety (other than mere novelty);
2. the need for the job to provide continuous learning for the worker;
3. the need to give the individual a discrete area of decision making;
4. the need for social support and recognition in the work;
5. the need to relate task and product to social life;

6. the need to believe in the job as leading to a desirable future.

(Emery, Thorsrud and Lange, 1965, p.5; van Beinum, 1966, p.63; Engelstad, 1969, p.353 in Davis and Taylor, 1972; Emery and Thorsrud, 1969, p.105; Trist, 1974, p.45.)

It is from these basic considerations that Emery (1963) drew up a list of thirteen "... hypotheses about the ways in which tasks may be more effectively put together to make jobs." (reprinted in Emery, Thorsrud and Lange, 1965, pp.5-9; van Beinum, 1966, pp.63-64; Hill, 1971, Appendix 2, pp.208-210; Emery and Thorsrud, 1969, Appendix V, pp.103-105; Trist, 1974, p.45.) Seven of these hypotheses concern individual task content, four are concerned with group organisation, and the two final items appear to have been added in 1969 and concern worker participation and promotion.

At the individual level, therefore, tasks should provide:

1. optimum variety,
2. a meaningful pattern (i.e. a single, overall or "whole" task),
3. optimum work cycle length,
4. scope for setting output and quality standards, with feedback of results,
5. inclusion of preparation and auxiliary tasks,
6. for the use of valued skill, knowledge and effort, and
7. some perceivable contribution to the utility of the final product.

And at the group level, organisation should provide :

for job rotation or physical proximity:

8. where tasks are interdependent, or
9. where individual jobs are stressful, or
10. where individual jobs do not make perceivable contributions to the utility of the end product;

and where jobs are interdependent they should, when grouped together:

11. (a) approximate an overall task which contributes to the utility of the end product,
 - (b) have scope for setting standards and receive feedback of results, and
 - (c) have some control over the boundary tasks.

In general the work organisation should also provide:

12. channels of communication to allow worker requirements to be incorporated in the design of new jobs, and
13. channels of promotion to foreman rank.

(Emery, 1963; Hill, 1971.)

Job characteristics thought to be desirable by the early British industrial psychologists such as Wyatt, Fraser and Stock, and by more recent American workers such as Herzberg and Lawler, may all be found in the above list. Creating work with these characteristics through the formation of responsible autonomous groups is, at least in theory, unique to the socio-technical systems approach. Reviewing the work of Trist and Rice along with some of his own research, Davis (1966) concluded that job characteristics which lead to "learnings and behaviors that seemed to provide the sought for organisation and job response qualities" fall into four categories:

- (a) responsible autonomy,
- (b) adaptability,

(c) variety, and

(d) participation.

(See also Davis, 1971c, p.425 in Davis and Taylor, 1972.)

Davis defines responsible behaviour as the individual's or group's acceptance of responsibility for:

1. the activities of the production cycle,
2. output rate,
3. quality of output,
4. quantity of output,

and the individual's or group's recognition of interdependence with others for effective performance of the production cycle.

Autonomous behaviour is defined as involving:

1. self-regulation of work content,
2. self-evaluation of performance,
3. self-adjustment to contingencies, and
4. participation in goal or objective setting.

(Davis, 1966 , p.42; Davis 1971a, p.170 in Davis and Taylor, 1972.)

If it is to incorporate adaptability, job content should be such that "the individual can learn from what is going on around him, can grow, can develop, can adjust." (Davis, 1971c, p.426 in Davis and Taylor, 1972.) Davis gives two reasons why jobs should have an adequate level of variety - the need to avoid creating a "deprived environment" with routine, repetitious tasks, and the need to ensure that adaptability is feasible. For this second reason, Davis cites Ashby's "law of requisite variety" which states that control is only effective where the controller (in this case the individual worker or the group) must be capable of matching the variety of behaviour

which the system (in this case the work) is capable of producing with an equally varied set of responses. The fourth category which Davis mentions, participation in decisions affecting an individual's work, is important, he argues, for learning and growth and hence for adaptability.

Davis' (1966) four categories of job characteristics cover virtually all of Emery's thirteen hypotheses and may be regarded as a more parsimonious expression of the same ideas.

The contention of Miller and Rice (1967) that the advantages of autonomous groups are limited by the rate of technological change has been discussed above. Other theorists have noted further constraints. Emery and Trist (1960) for example emphasise that maximum work group autonomy is not appropriate in all productive settings due to the requirements of the technology in use (p.288). Similarly, Herbst (1962) argues that the findings of Trist's coal-mining studies could not be extrapolated to other industries unless certain conditions prevail, i.e. autonomous work groups would only be effective where:

1. the work itself is autonomous, that is, it encompasses an independent and self-completing whole;
2. physical task boundaries are clearly definable;
3. the group members are capable of exercising control and responsibility; and
4. control is linked to variables that are observable and measurable (such as output and quality) rather than to those that are difficult to observe and supervise (such as activity and interaction patterns).

From his research in a small oil refinery in South California,

Susman (1970a), claims that the motives behind the formation of an autonomous group may affect performance. He distinguishes between "democratic work groups", which are "organised on the basis of democratic principles" and are the consequence of a democratic ideology, and "independent work groups", which have been set up for economic reasons and are the consequence of an economic decision by management. The results of either of these types of group can not, therefore, be applied to the other:

"The creation of democratic work groups is motivated by concerns for reducing worker alienation and apathy by allowing greater worker participation in the design of jobs. Awareness by members of democratic work groups that management was guided by a democratic ethic in permitting greater autonomy might create an atmosphere of high morale and cooperation which might not be found in independent groups, where autonomy is permitted for economic reasons." (Susman, 1970a, p.173.)

Autonomous group applications examined below do not fall neatly into Susman's two categories, having been based on both political and economic reasoning. Whatever the opinions of the researchers and consultants advocating these projects, however, final decisions concerning implementation which are left to management are generally based primarily on economic reasons.

Gulowsen (1971) seems to have been the only researcher to consider autonomy as a variable. He examined the functioning of eight autonomous groups comparing areas in which they did have autonomy, and those in which they did not. The criteria of autonomy (which Gulowsen formulated independently of the case study material) appeared to be arranged in the form of a Guttman scale; they were ordered as follows:

The group has influence on:

- | | |
|------------------|---|
| high
autonomy | 1. qualitative goals |
| ↑ | 2. quantitative goals |
| ↑ | 3. external leadership |
| ↑ | 4. additional tasks performed |
| ↑ | 5. when to work |
| ↑ | 6. production method (of the group) |
| ↑ | 7. internal task distribution |
| ↑ | 8. recruitment |
| ↑ | 9. internal leadership |
| low
autonomy | 10. production method (of individual members) |

Gulowsen argued that in order to reach a particular level on the scale, a group must satisfy all the criteria that precede that level on the scale of autonomy. In the groups that Gulowsen studied he found for example that if a particular group had influence on internal task distribution (criterion 7) it also had influence on criteria 8 to 10. Gulowsen's conclusion is that autonomy is a one dimensional property derived from two underlying variables - time span of decision and the system level on which decisions have an impact. The groups in Gulowsen's study having the most autonomy were groups of loggers and miners, who tend to work on time bounded contracts lasting for up to three months. During this period there tends to be no management interference as long as production is satisfactory. Gulowsen suggests that the term "autonomous group" be used to describe groups which negotiate and operate on the basis of such time bounded contracts, and that other types of groups (where appropriate) be referred to as "relatively autonomous". (Gulowsen, 1971, p.389 in

Davis and Taylor, 1972.)

Friedmann (1955) and Blauner (1964) had, amongst others, considered the effects of automation on job content. A number of writers have examined this topic from a socio-technical system point of view, and some difference of opinion now exists on the matter. There are those who, with Blauner, believe that everything undesirable in productive work will be removed with automation. Others advocate a more cautious, albeit pessimistic, view of its consequences.

A comparison of attitudes and jobs of workers in a conventional (in 1954) electricity generating plant and in a new highly automated plant led Mann and Hoffman (1960) to the conclusion that automation creates jobs which utilise employees' skills and abilities more effectively, and provide greater variety and opportunities for learning. Workers in the new plant ("Advance") reported higher levels of job satisfaction than those in the older plant ("Stand") and Mann and Hoffman claim that this was due to the combined effects of job enlargement and job rotation made possible by the technology of the new plant. Operators in the new plant were required to perform boiler, turbine and electrical switching operations which had previously been separate jobs.

Mann and Williams (1958, pp.83 to 90 in Davis and Taylor, 1972) arrived at similar conclusions about white collar work in their study of a change-over to electronic data processing (EDP). While jobs were generally not upgraded as a result, introduction of the EDP facilities eliminated routine and menial clerical jobs, creating new jobs which required new skills. These changes were accompanied, however, by feelings of loss of autonomy by both workers and supervisors as variations in work rate and tolerance of errors were reduced.

In a comparison (similar to that studied by Mann and Hoffman) between an original and later automated factory power plant, Marek (1962) attempted to show how with most of the manual tasks in the plant automated, the operators became "auxiliary controllers" with a high degree of responsibility for the production process. This involved greater use of the operators' perceptual and conceptual skills, and their ability to take the appropriate "feedback action" to rectify the process when necessary. In terms of ability to control the production process, Marek describes the work of the "auxiliary controller" as similar to that of the traditional craftsman. (Marek, 1962, p.62.) Williamson (1973) similarly argues that jobs in process industries (which represent "the summit of man's achievement in manufacturing") demand high skill and "represent the elite of manufacturing industry". (Williamson, 1973, p.30.) Process manufacturing is thus described as a model for other industries to emulate with respect to the nature of the work provided.

Davis argues that as automation takes over the routine "programmable" tasks, human intervention is required to deal with "unprogrammable" contingencies; workers in these conditions must, therefore, possess the requisite range of skills and abilities, be able to cope with unpredictable events, to work unsupervised, and to act on personal initiative. Automated industries, therefore, create jobs which require self-control and self-regulation. (Davis, 1971c, p.420 in Davis and Taylor, 1972; Davis, 1971a, p.162 in Davis and Taylor, 1972.) Davis finds this situation to be an extremely convenient one as technological and social forces appear to be working towards the same end:

".... for 'job characteristics that develop commitment' and thus promote the economic goals of the highly automated

organisation are exactly those that are beginning to emerge as demands for 'meaningfulness' from the social environment - participation and control, personal freedom and initiative." (Davis, 1971c, p.421 in Davis and Taylor, 1972.)

As a final example of this argument, Taylor's (1971a) longitudinal study of over 3000 respondents in two different organisations (an oil refinery and an insurance company) tries to show that "sophisticated technology" is more conducive to the formation of autonomous groups, and to participative management:

"It would seem that automation does in fact provide the potential or opportunity for enhanced worker discretion, responsibility, intra-work-group autonomy, inter-dependence and cooperation in both blue- and white-collar organisations. In fact, what seems to be happening is that lowest level jobs are becoming more like traditional supervisory roles." (Taylor, 1971a, p.7; Taylor, 1971b, p.393 in Davis and Taylor, 1972.)

These researchers have tended to generalise about the effects of automation on job content from single case studies (Taylor being one exception). But Emery (1959), noting that automation changes task requirements from the use of gross motor skills to perceptual and conceptual skills, argues that other characteristics of the work depend upon the type of automation introduced. Thus where physical effort is still required to complete the work of the machinery, the worker is likely to experience a considerable increase in job pressure and probably also in physical fatigue. Where physical labour is eliminated but self-correcting controls have not been incorporated in the machinery the pressure upon the worker to maintain surveillance is increased. Frequently there is no direct relationship between speed of production and job pressure; the operator has to be on the constant look-out for deviations from process norms. Emery concludes, therefore, that "...technological

changes towards greater automaticity promise no automatic solutions of the human problems of industry." (Emery, 1959, p.196 in Davis and Taylor, 1972.)

Cooper (1972) also suggests that the "utopian" work conditions described by, for example, Mann and Hoffman, Marek, Davis, Taylor and Williamson, may be characteristic of fluid processing technology alone, e.g. in petroleum refining or chemicals manufacture (and possibly in electricity generating). Cooper notes the "trend of automation to assimilate the information - processing functions characteristic of skilled work." (1972, p.154.) This development will tend to eliminate skilled work leaving operators on lower skill levels requiring fewer perceptual and conceptual abilities (understanding and synthesising skills). The combination of operating and maintenance tasks into single jobs, Cooper suggests, is one means of providing job enlargement; but automation will not automatically create this opportunity without planned intervention.

Thus it would seem that claims for the benefits of automation in ameliorating the alienating characteristics of production work should be treated with scepticism. The outcome of technological change in the direction of process manufacturing methods is equivocal and it is not possible to generalise about the effects of automation on job design. This is an area of continuing interest to socio-technical system theorists for obvious reasons, and this review has touched upon only a section of the literature on automation and its implications. The main concern here has been to illustrate the relationship between automation and desirable job characteristics (including autonomous group formation) and, it is hoped, to show that there is no simple relationship. The next section deals with a

further source of misunderstanding concerning autonomous group working, and this has arisen over the introduction of "group technology" which has no relationship with socio-technical systems theory whatsoever, and has only an indirect relationship with autonomous group working.

Group Technology and Autonomous Group Working

A number of writers in this area have equated "group technology" (or "cellular manufacture") with autonomous group working; this is a major source of confusion which should be resolved before this review continues. Edwards and Schmitt (1973), for example, advocate the "cell system" of work organisation, using groups of six to eight workers who control to a certain extent the work which they are doing. Williamson (1973) argues that in batch manufacture the cellular system has the following advantages:

1. increased flexibility of production;
2. reduced set-up times;
3. increased ratio of processing time to total throughput time;
4. reduced overall manufacturing time;
5. reduction in quantities of work in progress;
6. improved communications;
7. faster reaction to errors;
8. improved task identity; and
9. fostering of "skill, team spirit and pride in achievement."

(Williamson, 1973.)

The "cell system" was first described by S.P. Mitrofanov(1955,

translated from the Russian in 1966). He was concerned with the technical rather than with the behavioural advantages of organising batch production around groups of components which undergo similar production processes:

"The problem here is to create a method of technological process development, equipment planning and efficient setting of the machine tool, so as to ensure the most profitable technological planning of production in the shortest time." (Mitrofanov, 1966, p.15.)

The solution to this problem, through group technology, is summarised thus:

"The group processing method is based on the classification and isolation of such part groups which, in processing, require identical equipment, common tooling and similar set up of the machine tool." (Mitrofanov, 1966, p.16.)

The "group" in "group technology", therefore, is a group of components with common production requirements, not a group of workers who operate in comparative autonomy. Now in setting up "manufacturing cells", i.e. groups of machinery which will produce exclusively one type of component, it is possible to have this machinery operated by a composite, internally led group of workers. Such cells, according to Williamson, become:

".... pockets of self-contained responsibility in which man's skill, intelligence and enthusiasm are harnessed in somewhat specialised working groups." (Williamson, 1973, p.33.)

The point, however, is that group technology does not in itself imply or necessitate the creation of autonomous groups of workers. It is a technically advantageous way of organising batch manufacture which appears to afford opportunity for the establishment of autonomous group working in the manufacturing cells created.

Socio-Technical System Analysis and Design

Socio-technical system theorists have formulated a 9-step "method of socio-technical analysis" for the redesign of production tasks, and a 7-step "method of role analysis" for use in service or advisory departments.

The Tavistock Institute formed a study group (comprising Emery, van Beinum, Davis, Herbst and Engelstad) to examine possible frameworks of analysis to help system designers with job structuring or work organisation. The study group reported in 1966. Their initial conclusions, based on a number of work organisation applications, were that:

1. general principles for designing jobs and work organisations could be formulated;
2. a given technology could be analysed to determine means of jointly optimising the social and technical systems;
3. experience with one technology could not be directly transferred to another; and
4. diffusion of the findings and further application would be inhibited by inadequate conceptualisation.

The analysis and classification of "unit operations" was first considered to be a possible solution (Emery, 1966). Unit operations are:

"...process-oriented functional elements reflecting processing requirements for transforming materials or information into products or services. They describe the processing stages to be completed, i.e. work to be done, by men and machines." (Davis and Engelstad, 1966, p.4.)

In the terminology of Miller and Rice (1967) these are "operating systems".

The unit operation approach, however, required extension to take account of environmental and human factors relevant to the socio-technical unit under analysis. One of the fundamental parameters of production system design for the socio-technical theorist is the ability to adjust to environmental changes. In his discussion of the value of self-maintaining autonomous groups, Herbst (1966) argues that a design that specifies every variable of the system removes that system's self-regulating properties. He advocates instead "critical specification design" in which only a minimal set of variables is specified, others being regarded as "free variables". In other words if a system (work group) is to behave in a self-regulating manner, its functioning must not be so constrained that change is difficult or impossible. Herbst's concept of critical specification design is an attempt to identify "the minimal set of conditions required to create viable self-maintaining and self-adjusting production units." (Herbst, 1966, p.9.) The composite, internally led autonomous group, claims Herbst, provides the optimum solution. It was from these considerations that the 9-step method of socio-technical analysis was derived. It was developed in the course of the company development programme at Shell UK, and in particular through the design of a new oil refinery at Teesport. A full description of that development programme is to be found in Hill (1971) who also gives the 9-step analysis (in Appendix 5, pp.230 to 243) which will be briefly described here:

Step 1 : Initial Scanning.

The main characteristics of the production system and its environment are identified and the main problems are determined.

This step of the analysis covers layout, organisation structure, system inputs and outputs, the transformation process, the main variances and their sources, the relationship between the production system and the department in which it exists, and production and social objectives.

Step 2 : Identification of Unit Operations.

The main stages or transformations in the production process are identified. The purpose of each unit operation is described in terms of its inputs, transformations and outputs.

Step 3 : Identification of Key Process Variances and their Interrelationship.

Variances are defined as deviations from standard or specification. At this stage, the analysis is concerned only with variances arising from raw material or from the nature of the process itself; breakdowns, plant faults and "human factors" are not considered at this stage. Not all variances are taken into account, only those which impinge significantly upon system performance:

".... it has been found that in any production system there are a large number of variances that have either no effect or a comparatively minor effect on the ability of the production system to pursue its objectives."
(Hill, 1971, p.232.)

Four criteria are suggested for determining the "key" variances and concern their effect on output quality and quantity, operating costs and social costs (stress, effort, hazard).

Step 4 : Analysis of the Social System.

The major groupings (informal and formal) in the social system and their interrelationships are identified. The object here is

".... to show the extent to which the key variances are at present controlled by the social system...." (Hill, 1971, p.233.) It is suggested that a "Table of Variance Control" be drawn up; this Table lists each key variance identified and records:

1. where in the process it occurs;
2. where it is observed;
3. where it is controlled;
4. by whom it is controlled;
5. what tasks are necessary to control it;
6. the information necessary, and its source, that enables these control activities to be carried out.

A final column on the Table of Variance Control is reserved for "Hypotheses for Job Design". This is to be used for recording suggestions generated during the completion of the Table.

This step also incorporates an analysis of (a) ancillary activities, (b) layout and dispersion of workers in space and time, (c) workers' knowledge of each others' roles, (d) the payment system, and (e) areas of frequent mal-operation.

Step 5 : Men's Perceptions of their Roles.

(There was apparently no female labour in the refinery at Teesport.) This step is linked with Step 4 and continues the analysis of the social system. The psychological requirements of the workers are determined by interview, and further job design proposals are developed.

This step completes the analysis of the production system itself, and it is to be expected that a number of job design proposals will have emerged.

Step 6 : Maintenance System.

The impact of "external" systems upon the production system is now examined. This may affect the redesign proposals and/or produce further ones. Variance due to maintenance (arising in the production system) is identified and present and potential methods of control are examined.

Step 7 : Supply and User Systems.

The emphasis here is again on how supply and user systems affect the production system. Variance arising in the supply and user systems is examined along with means of controlling it.

Step 8 : Environment and Development Plans.

This Step concerns identification of forces operating in the wider environment which impinge upon the production system's ability to achieve objectives, or which are likely to lead to a change in objectives in the foreseeable future. Any development plans affecting the social or technical systems will be scrutinised, including any general policies and practices relating to the production system which have not yet been taken into account.

Step 9 : Proposals for Change.

At this point an "action programme" is drawn up incorporating all the hypotheses and proposals developed during the analysis. With this, the analysis is complete and the next stage is implementation.

A "method of role analysis", similar to that for production tasks, was also developed "... as an alternative method of analysis for departments where no continuous process exists, such

as service or advisory departments." (Hill, 1971, p.244.)

This process has only seven steps and these are:

1. General scanning;
2. The objectives of the system;
3. Analysis of roles in the system;
4. Measurement of roles against psychological requirements;
5. Grouping of roles;
6. Development of change proposals;
7. Management by objectives.

This procedure is clearly similar to that used to analyse production tasks. The seventh step - management by objectives - is necessitated by the difficulties in establishing performance measures for this type of task, and providing adequate feedback of results.

A summary of the 9-step analytical model is given by Trist (1974, p.46.), and Taylor (1975) has produced a simplified version using the following five steps:

1. Scanning;
2. Technical analysis; identification of -
(a) unit operations, and (b) key variances;
3. Table of variance control;
4. Social system analysis: the internal role network, gross boundary role network, and individual role analysis are examined;
5. The socio-technical design.

(Taylor, 1975.)

Autonomous Group Working : Applications

Here it is necessary to divide the relevant literature geographically since the theory with which we are dealing has been applied extensively in Europe and particularly in Scandinavia. The repetition involved in describing all or most of these studies will be avoided by describing in detail one study carried out in Norway and one from Sweden. These are chosen as illustrative of work organisation projects where autonomous groups have been established.

Norway

By the end of the 1950's no further opportunities had arisen for the Tavistock Institute to conduct field experiments in Britain. Socio-technical system studies, however, were given a "new dimension" with the Institute's involvement in the Norwegian Industrial Democracy Project. (Trist, 1971, p.86.) A Joint Committee of the Norwegian TUC (the LO) and the Norwegian Employers' Federation (NAF) had been formed to study the question of industrial democracy. In the winter of 1962-63 that Committee invited a combined research team from the Institute for Industrial Social Research in Trondheim (Norway) and the Tavistock Institute to undertake a study of the experience of Norwegian industry with employee representation on company boards. This part of the Project was termed "Phase A" and its conclusions were first published in Norway in 1964, and in English in 1969 (Emery and Thorsrud, 1969).

Only a few Norwegian companies had appointed employee directors. Twelve such employee representatives from five large Norwegian

manufacturing firms were interviewed and it was found that (a) communications between representatives and their electors were poor, and (b) the representatives often found themselves adopting the view of the Board as a whole on certain matters. (Thorsrud and Emery, 1966.) Contrary to the original objectives of these schemes they had produced no increase in participation by shopfloor workers in company affairs, no increase in productivity, and no decrease in worker alienation:

"The majority of employees were not involved or committed to the representative activities. Those who were committed would soon change from being representatives of employees and become ordinary board members. In cases where this was not so, the board seemed not to fill its primary function." (Thorsrud, 1968, p.121.)

Due to the apparent lack of success of employee board representatives, attention was switched to "The other aspect of industrial democracy - the democratisation of relations on the job" (Thorsrud, 1968, p.123.) This was to be termed "Phase B" of the Project. The two tasks requiring immediate attention were first, to initiate experiments in work organisation (i.e. to implement the principles outlined above) and second, to establish a network for the diffusion of the results of these experiments. The latter proved to be the more difficult task; the problems of the diffusion process are described in Thorsrud (1974).

Two industries were selected for initial experimentation - the metal working and pulp and paper industries - because of their importance to the Norwegian economy. One of the most important selection criteria for plants considering starting an experiment was a good labour relations record. One problem common to all the sites eventually chosen was the attitude of management towards the proposed

changes. They were conscious of the irreversible nature of the steps which they were about to take and the progressive erosion of their prerogatives which this involved. Each stage of the experiments had, therefore, to be designed such that management, and workers, did not feel that they had become over-committed. They were asked to make a series of small, step-wise commitments rather than one comprehensive transition.

The four plants selected for the initial experiments were:

1. Christiana Spigerverk, a wire drawing mill in Oslo;
2. Hunsfos, a pulp and paper mill in South Norway;
3. Nobø, an electric panel manufacturer in Trondheim; and
4. Norsk Hydro, a chemicals and fertilizer manufacturer.

We shall examine here the first of those experiments which was selected on the grounds that if improvements could be made here they could be made anywhere (Trist, 1974, p.43). As explained below, this experiment was so successful that it had to be discontinued. The main report of this experiment is in Emery, Thorsrud and Lange (1965).

The site chosen for the first experiment was the rather dilapidated wire drawing mill belonging to Christiana Spigerverk, a large metal manufacturing company. This section processed thick wire which was run at high speed through a series of dies to reduce its diameter, producing coils of thinner wire. The job of the wire drawer consisted of long periods of inactivity interrupted by unpredictable breaks in the wire. When these breakages occurred, the operators were required to work at speed to correct the fault and get the machine running again. The operators worked independently - one man, one machine - and did not assist one another when they

had nothing to do at their own machines. Apart from repairing breakages, the work was routine; batches of wire for reduction had to be welded together, and finished wire had to be removed from the machine.

The wire drawers found their work boring. It lacked variety and was generally unattractive. The constant threat of breakage, however, generated an undesirable tension. The job seemed to have one positive aspect - some workers enjoyed being "master of their own bench." (Emery, Thorsrud and Lange, 1965, p.16).

The workers' overall attitude to their job was, therefore, ambivalent:

"It would seem, on balance, that while some individuals may have found a positive value in the lack of interaction on the job, the majority regret it but put up with it because they do not in any case expect to find easily other industrial jobs that are, all told, much better." (Emery, Thorsrud and Lange, 1965, p.17.)

Some had found a source of satisfaction in the job, others passively tolerated it.

The first attempt to improve the job through autonomous group working met with considerable resistance and the conditions specified for the experiment were not fully met. The basis of the change was the allocation of a group of workers to a group of machines (rather like Rice's textile workers, although the initial conditions were different). The basic experimental conditions were to have been:

1. seven benches run by six men;
2. a guaranteed minimum wage 1 per cent above average, and an incentive payment for production above average (these averages were both calculated over the four weeks preceding the start of the experiment);
3. the experimental group would consist of volunteers approached

- through the shop stewards;
4. work would be shared by the group;
 5. the basic layout would not be changed (although this would have been desirable);
 6. the group would be allocated a full time maintenance man;
 7. trainees would only be attached to the group later;
 8. production and earnings would be calculated daily and displayed on a chart in the work area.

These conditions were only partially achieved. The "rule" of "one man, one machine" proved impossible to break and argument broke out over the payment system. Voluntary participation and co-operation could not be obtained and the shop stewards had some difficulty in "persuading" the workers to "volunteer". The operators who took part in this phase of the experiment did not regard themselves as volunteers, and one man claimed to have been forced to take part. The operators displayed a marked preference for the traditional work system and work sharing in the group was restricted to rotation and some mutual help with breakages.

The researchers attributed this lack of success to the characteristics of these particular operators:

"The high turnover of trainees and new workers (six out of ten quit within the first eighteen months of employment) suggests that not only had most of these men become habituated to this work, but they had been selected out by the system as the ones least put off by the isolation of the job and its peculiar rhythm of indolence and exasperating wire trouble." (Emery, Thorsrud and Lange, 1965, p.26.)

A second experimental group was, however, set up with genuine volunteers and a renegotiated incentive scheme. This group was one man short, due to illness, but the group agreed to operate the extra machine anyway. This stage lasted only two weeks, but a much

closer approximation to the ideal experimental conditions was achieved, this time with four men operating five machines. Productivity increased, although it did not reach the level which would normally have been attained with the extra man. The operators were content with the new work arrangements but there was some dissatisfaction with payment. If the men had been given fair payment for the production achieved through group working they would have been among the highest paid men in the plant. The other highly paid workers would then have requested regrading (upwards), but as the plant as a whole was not producing more this would not have been possible. This would also have violated nationally agreed rates.

This experiment had to be discontinued, therefore, because the problems created by improved productivity had not been fully anticipated. This did not inhibit other autonomous group working experiments at Christiana Spigerverk, some of which are outlined by Gulowsen (1971). The other experiments went ahead as planned; the Hunsfos experiment is reported in Engelstad (1969), the Nobø experiment is reported in Thorsrud (1968), and the experiment at Norsk Hydro is reported in Gulowsen (1969, 1973). Brief accounts of these are also given by Thorsrud (1968), Trist (1974) and Jenkins (1974).

Researchers in the natural sciences may be heard to claim that there is no such thing as a failed experiment - it can always be used as a bad example. The experience at Christiana Spigerverk is a good example of what may go wrong with a work organisation project when an inappropriate group of workers is selected for the experiment, and when insufficient attention is given beforehand to the consequences of the experiment fulfilling its objectives.

The comparative success of these experiments has been widely publicised in Scandinavia and this has marked the third phase of the Project - the diffusion process. The Joint Committee which sponsored the Project has been transformed into a National Participation Council, and a Norwegian Parliamentary Commission on Industrial Democracy was established (see Trist, 1971). A number of limited experiments began in the 1970's and more recent applications have occurred in the Norwegian shipping industry concerning the organisation of work on bulk carriers (Thorsrud, 1974). The Norwegian experiments, however, appear to have been more influential in Sweden than in Norway.

Sweden

Emulating their Norwegian counterparts, the Swedish Employers' Confederation (SAF), the white-collar central union organisation (TCO) and the central labour confederation (LO) established a "Development Council for Co-operation Questions" in 1966. The Council's objective was to carry out experiments of various kinds similar to those conducted in Norway. Their major impetus in fact seems to have been generated by the published results of the Norwegian experiments. (See, for example, Jenkins, 1974, p.261.)

Barritt (1975) assesses an SAF report on some 500 Swedish experiments in job design; Valéry (1975) estimates that over 1000 such experiments have been started, noting that many have failed and that many have been used for publicity purposes. Despite this apparent breadth of experience, Valéry suggests that in Sweden the work organisation "movement" as such rests on the experience of only three companies - Atlas Copco, Volvo and Saab-Scania. (Osbaldeston

and Hepworth, 1975, p.17, make the same point.) The experiments which these companies have set up have become major "management tourist" attractions. Similar but less well publicised projects have been successfully implemented in The Grangesberg Company (a large steel, mining and shipping concern) and in Orrefors Glass Works. Of the three best known case studies, Volvo has received by far the most publicity (at least in publications in English). Very little information, however, is available about the Atlas Copco experiment (see Jenkins, 1974, and Valéry, 1974). The Saab-Scania experiment will be used here, therefore, to illustrate the work organisation approach in Sweden.

The Saab-Scania Group's experiments in work organisation began in 1970; 40 production operators in the chassis shop of a new truck factory were divided into small composite production groups (Norstedt and Aguren, 1973). Group members rotated themselves between different tasks, and also carried out maintenance and quality control functions. In order to involve operators in the development and improvement of work methods and conditions, "development groups" were also established. Each group includes a supervisor, a work study man and a number of operators. These groups meet monthly and issue a report on decisions made stating who is to be responsible for any action to be taken. The objectives of this experiment included reductions in labour turnover and absenteeism and increased productivity. The experiment was considered a success for a number of reasons, e.g.:

1. this method of working spread to the rest of the chassis works (employing about 600 manual workers);
2. productivity increased;

3. unplanned stoppages were reduced significantly;
4. costs were reduced to 5 per cent below budgets;
5. product quality improved;
6. over 4 years, labour turnover in the chassis shop was reduced from 70 per cent to 20 per cent;
7. absenteeism remained unaffected;
8. communication and co-operation between management and workers improved through the "development groups".

The Saab-Scania Group's better known experiment took place in their new engine factory at Södertälje (which began production in 1972). From the results of their earlier experience, the company decided to design the work organisation of the new factory from scratch and to design the factory layout accordingly. The final layout consisted of an oblong conveyor loop which transported the engine blocks to seven assembly groups each with three people. There is also an island of potted plants enclosing a cafe alongside the assembly line, where workers have the use of a telephone. (Thomas, 1974.) Each group has its own u-shaped guide track in the floor to the side of the main loop; engine blocks are removed from the main track, completely assembled by the group, then returned to the main track. The engine blocks arrive with their cylinder heads already fitted and these groups are concerned with the final fitting of carburettors, distributors, spark plugs, camshaft, chains, etc. There are seven groups altogether (one is a training group) made up from 36 workers most of whom are female. Each group thus assembles a complete engine from start to finish, deciding amongst themselves how the work is to be distributed within the group. Each group has its own guide-track which is not mechanically driven and the overall work

cycle for the group can be 30 minutes, compared with the 1.8 minute cycle time of individual jobs on the conventional assembly line. At the time of their writing, Norstedt and Aguren (1973) claimed that evaluation of the experiment was not possible, but Lindestad and Norstedt list some of the expected advantages and disadvantages.

advantages:

1. production is more insensitive to disruption;
2. group working is stimulating, provides opportunities for individuals to expand their skills, and work can be adapted to suit individual competence;
3. fluctuations in production volume do not require extensive and costly line rebalancing measures, and changes in capacity can be achieved by varying the number of group members (up to 6) or by increasing the number of groups;
4. since work content can be adapted to each individual, this will provide better recruitment opportunities.

disadvantages:

1. the new layout takes up more floor space and ties up more material than the conventional assembly line;
2. investment costs are therefore higher;
3. work efficiency is reduced because of the reduction in degree of specialisation.

(See Lindestad and Norstedt, 1973, p.21.)

Writing a year later, Valéry (1974) claimed that the biggest saving from this experiment had been due to reduced labour turnover; Saab-Scania are saving an estimated 65,000 Swedish Kroner (Sk) per annum on recruitment and training costs. Reductions in absenteeism

are saving the company an additional 5,000 Sk per annum. Valéry also reports that the factory achieved a lower reject rate, easier production balancing, lower cost of assembly tools and a reduction in the number of instructors and relief workers required. Reminiscent of Herbst's description of the coal face worked by an autonomous group, Thomas (1974) remarks on the quiet and cleanliness of the Södertälje factory and its relaxed and unhurried atmosphere.

Additional information concerning this particular experiment can be found in Wild (1975), Jenkins (1974) and Ruehl (1974). Wild (1975) cites a number of references describing Volvo's experiments in re-designing car assembly; amongst the more easily obtainable are Jenkins (1974), Foy (1974), Ruehl (1974) and Valéry (1974).

Europe

Experience of work organisation in other European countries again seems to be restricted to a few well known companies whose efforts in this area have not suffered from lack of publicity. Agersnap et al (1974) report on a number of projects undertaken in three companies in Denmark (Højbjerg Machine Factory, Philips Radio and N.Foss Electric). Philips is actually based in Holland and the work organisation projects in its Dutch factories are well known (Philips Report, 1969). This company has investigated a number of trials of job rotation, enlargement and enrichment, and autonomous group working. Successful projects in the Swiss machinery and metal processing industry have also been reported (European Foundation for Management Development Fourth Annual Conference, 1975). Amongst European car makers, Fiat of Italy has also implemented successful experiments in work organisation (Ruehl, 1974). The studies

mentioned so far have dealt exclusively with blue-collar work organisation. Osbaldeston and Hepworth (1975) managed to locate only 25 white-collar experiments in the course of a year's research throughout Europe (including Britain). Nine of these were in Scandinavia. Wilkinson (1971) provides a sketchy survey of European "experiments in motivation" up to his date of writing.

America

A number of "group working" experiments in job design have been undertaken - see Kuriloff (1963), Sorcher and Meyer (1968), Gooding (1970), Weed (1971), Huse and Beer (1971) and Sirota and Wolfson (1972b). Some of these references may be familiar - they were mentioned in the earlier section on job enrichment. These experiments were not, therefore, motivated by socio-technical system theory. One American study which does have this theoretical background is that reported by Walton (1972) who describes the establishment of autonomous processing and packaging teams in the new plant of a large pet-food manufacturer. American management has concentrated on job restructuring techniques and on job enrichment in particular.

Britain

The major direct contribution of the Tavistock Institute to this area in Britain in recent years has been their participation in the company development programme of Shell UK Ltd. Low productivity and high labour costs, attributed to negative employee attitudes to the company, and the existence of a multitude of restrictive practices, led to the formulation of two solutions:

- (a) to adopt a participative style of management to improve morale, and
- (b) to begin comprehensive productivity bargaining to eliminate or reduce restrictive practices.

The Tavistock Institute (and Emery in particular) was involved in drawing up a statement of the company's philosophy and objectives, for disseminating this to all members of the company, and in the direct application of this statement in the design of a new refinery at Teesport (Hill, 1971; Taylor, 1972).

Other British group working experiments have included:

1. establishment of groups of 4 to 5 workers making complete products in a domestic appliance factory in Hamilton, Scotland (Leigh, 1969);
2. establishment of teams of 7 to 8 workers making television sets at the Pye factory in Lowestoft (Manufacturing Management, 1972);
3. establishment of groups of up to 25 workers making complete sub-assemblies or main assemblies in a Hoover factory (Dyson, 1973).

More recently, the Industrial Training Research Unit at Cambridge have been introducing autonomous work groups in the clothing industry:

- at Ladybird (Northern Ireland) Ltd., in Belfast (Waldman and Larkcom, 1974), and
- at Emcar in East Anglia (Pearcey, 1976).

The socio-technical systems approach to job design has had a far greater impact on Scandinavian industry than it has had in its country of origin. Two sets of cultural factors pertaining to

Scandinavia, and to Sweden in particular, appear to have contributed to this - a highly formal, centralised industrial relations system, and the Scandinavian industrial environment (or "climate") as a whole. Scandinavian industrial relations systems are dominated by powerful, formal centralised bodies representing employers and unions. Procedural agreements are established at national level. Unlike Britain, the unions are organised on an industrial basis as opposed to an occupational basis and there is a relative absence of demarcation problems. The stability of the balance of power between the two sides has also assisted co-operation between them. These countries have generally higher standards of living, education and welfare state benefits. Labour shortages make techniques like job design attractive to management as a means of attracting and retaining labour. And increased job security also reduces resistance to this type of change.

There are indications that this lack of application of work organisation in Britain is a trend which is being reversed. Mention has been made of the Tavistock Institute's involvement with Shell, and the work of the Industrial Training Research Unit in the British clothing industry. The Work Research Unit of the Department of Employment is now charged with promoting research into and advising on the application of job design techniques in general, including the job restructuring approaches discussed above and the socio-technical systems approach. (See Jessup, 1975.)

The Socio-Technical Systems Approach : Criticisms

From their survey of white-collar work structuring experiments in Europe, Osbaldeston and Hepworth (1975) conclude that European

applications have in general been more far reaching than those undertaken by British companies. This they attribute to the cultural constraints on the transferability of such experience from country to country, and to the disinterest of British trade unions. They also found that, compared with American studies in job enrichment such as that of Ford (1969) there has been very little true "experimentation" in Europe:

".... instead of rigorous experimentation, there is often found a continuing change process, whereby an organisation constantly adjusts and adapts itself to its environment, both external, in the shape of changing legislation, market forces and social values, and internal, in the shape of changing expectations of a more educated work force, pressures from trade unions, and the introduction of new technologies." (Osbaldeston and Hepworth, 1975, p.1.)

Job restructuring, on the other hand, is generally regarded as a single time-bounded intervention.

The Tavistock workers have been criticised for producing ostensibly academic books and papers based on data gathered in the course of consultancy work. Following such criticism, for not making his working methods explicit in his 1958 book, Rice included extensive appendix material in his later book (1963) giving examples of his original working notes as they were presented to the Mill management at the time. A similar degree of openness regarding the source of data is also to be found in the case studies of Miller and Rice (1967). Rose (1975) is perhaps unduly critical in suggesting that the concepts of socio-technical system and organisational choice

".... can be interpreted as an attack on the trained incapacities of production engineers and as an advertisement for social scientific industrial consultants."
(Rose, 1975, p.213.)

Rose further suggests, however, that the concept of organisational choice is not accurate: the argument of Trist et al (1963) was that

management is not wholly constrained by the technology of a production process in organising those who will operate it; i.e. with a given technology there are alternative forms of organising the work. But the alternatives that Trist et al advocate are also more effective ways of working. So the "choice" that management is faced with is not merely between two or more organisational forms but between inefficient and more efficient forms. Rose argues that this is not really a choice at all.

The scepticism of British trade unionism towards job design and autonomous group working has been mentioned above. The Head of Research of the Amalgamated Union of Engineering Workers, Tony Banks (1974) expresses this attitude clearly. He is critical of the management bias in the job design literature. Although increased satisfaction is stressed as an advantage, group working is invariably introduced to solve serious management problems. Banks also points out that "group working" is frequently no more than job rotation and that "autonomy" can vary widely in meaning (see Gulowsen, 1971, referred to above). Banks criticises the way in which group working projects can, as in Scandinavia, be used as publicity vehicles and become "tourist attractions". In one of his more sarcastic passages Banks claims that:

"Another similarity in most of the group working schemes has been the predominance of unskilled and semi-skilled female employees. Perhaps group working initially appeals to the highly developed group instincts of the average female! In conjunction with this it is interesting to note the number of occasions group working commenced with a re-decoration of the work area based on the suggestion of the employees involved in the experiment." (Banks, 1974, p.11.)

Banks discusses four more serious disadvantages of group working:

1. That the delegation of responsibility down the hierarchy

may increase stress and work load.

2. That the creation of groups with added responsibility may induce friction between groups and individuals and "undermine workshop comradeship and unity".
3. That group working reduces the number of supervisory jobs (and thus reduces labour costs - a managerial advantage).
4. That promotion opportunities for shopfloor workers are reduced.

With the exception of the second, these criticisms could also apply to job restructuring techniques. With either approach, these criticisms do not necessarily apply as the circumstances of each job design project vary. In one of Ford's (1969) job enrichment experiments, for example, the number of promotions out of the "experimental" group were much higher than those from the "control" group. Bank's criticisms are generalisations which will not apply in every case. The outcome of the experiment at Christiana Spigerverk in Norway lends weight to Bank's second criticism. The wage differential which the experimental group established created dissatisfaction amongst other groups of workers in the factory. Herzberg's (1974) argument against "social job design approaches" is based upon his concept of the "tyranny of the group". Precisely what Herzberg means by this is not clear, but he seems to imply that the development of the individual may become submerged in the requirements of the group as a whole. The majority of the authors cited in this section on work organisation on the other hand would claim first, that autonomous group working is a more powerful technique than individual job restructuring in providing for human needs, and second that group working is intrinsically flexible and thus more able to cater for individual differences in ability and need.

It is not possible to end this section without mention of David Silverman's (1970) celebrated critique of socio-technical system theory. Silverman is a sociologist and his book, "The Theory of Organisations : A Sociological Framework" is concerned with the subject matter of sociology as a whole and with how sociologists should go about their business. Here we shall concentrate on his view of socio-technical systems theory as a means of examining behaviour in organisations. Silverman argues that by concentrating upon technology and social factors, the socio-technical systems approach diverts attention from the wider social influences on worker behaviour; by concentrating on "objective" organisational properties, individuals' subjective definitions of their environment are ignored. The sociologist studying organisational behaviour (and other forms of social behaviour), Silverman argues, should take account of these factors which the socio-technical systems approach obscures. An additional difficulty with socio-technical systems theory lies in what Silverman terms reification, that is ascribing organisations with biological needs for survival, stability and growth. Organisations cannot have such needs, and cannot act independently of their members. The usefulness of the theory claims Silverman "depends on how far one is prepared to concede that social institutions are similar to biological organisms and that their functioning is best understood in terms of a series of adaptations to an often hostile environment." (Silverman, 1970, p.119.)

Silverman argues that the socio-technical systems approach has four "serious limitations" which are:

1. The confusion between "Is" and "Ought" propositions.
Are technology, market forces and human needs to be regarded

as variables which actually shape or determine organisation structure, or are they important variables requiring study and which must be considered when attempting to undertake organisational change? It is one thing to argue that these variables ought to be important in determining organisation structure, but it does not then follow that these variables indeed are determinants of organisation structure.

2. The role of the consultant in prescribing for organisational problems.

Silverman raises the familiar criticism of "the dual role of many socio-technicists as academic analysts and as consultants to business organisations". (Silverman, 1970, p.121.) His main concern here is with the lack of a sociological perspective in much of the socio-technical literature, and he speculates on the influence which the consultancy role may have on orientations to the questions of constructing efficient organisations. The consultant, argues Silverman, "is likely to be immediately concerned with social rather than sociological problems" and "theories and empirical materials which do not have a direct bearing on the task at hand may not be taken up". (Silverman, 1970, pp.121-122.) Theories generated apply to commercial organisations and are difficult to apply to other types of organisation, and the problem solving bias of the consultant leads to an eclectic use of perspectives and techniques. From the sociologists point of view, this is unsatisfactory.

3. The nature of members' attachments to organisations.

Silverman argues that:

"The weakest part of the Socio-Technical Systems approach is the regular failure of its proponents to discuss adequately the sources of the orientations of members of organisations." (Silverman, 1970, p.123.)

Miller and Rice (1967) concentrate on affiliation and security needs of an organisation's members and discuss sentient groupings which satisfy these needs as producing loyalty and commitment from their members. Silverman points out that there are a number of types of involvement in organisations and that the socio-technical systems view is confused and restricted.

4. The nature of the environment of an organisation.

Again Silverman argues that the socio-technical systems approach is restricted in that the organisation's environment is analysed in purely economic terms, as a series of market pressures affecting organisation structure. Members' orientations to the organisation, argues Silverman, are determined by their perceptions of the organisation and these are influenced by their extra-organisational experiences. The environment of an organisation, therefore, affects its internal functioning through more than economic pressures.

Silverman does not, of course, examine socio-technical systems theory as an approach to job design. Some of his remarks will be taken up in the Conclusions at the end of this Chapter where the disadvantages of this approach to job design will be examined in more detail.

In addition to these criticisms of work organisation and socio-technical systems theory, several points may be made in summary of this approach as a whole.

1. The work organisation approach to job design incorporates an explicit model of the organisational framework which is to be changed - it adopts a model of organisation structure and functioning. Herzberg's contribution to the theory of job design was discussed above in terms of the components which his theory included. The work organisation approach, therefore, has all the basic components of Herzberg's theory plus a model of organisation structure and functioning. That this model should be a socio-technical systems one has been severely criticised, for example by Silverman; but as with Herzberg, it is perhaps more important that such a component is considered necessary at all than whether or not the design of the component is appropriate.
2. Job restructuring approaches to job design have not incorporated explicit models of organisation structure and functioning. It has, therefore, been difficult to predict in advance the effect on supervisory jobs of job restructuring at operator level. (Lawler, Hackman and Kaufman, 1973 is a good example.) In using the primary work group, or the operating system, as the basic unit of analysis, the work organisation approach has similar difficulties in predicting the impact of changes on higher level jobs and on jobs in adjacent groups or operating systems. It is difficult, for example, to discover what effect (if there was any) composite group working in coal mining had on the tasks of other underground workers involved on auxiliary tasks. (Trist et al, 1963.)
3. Autonomous group working seems to be a more powerful job design technique than any of the job restructuring approaches.

It offers more scope for introducing desirable work characteristics than methods directed at individual jobs.

4. Applications of the project type organisation suggested by Miller and Rice (1967) are probably more numerous than the incidence of reports of them in the literature would suggest. A number of professions (including, for example, accountants and civil engineers) often organise work teams in this way to deal with individual contracts. No reports of manual workers being organised like this were encountered in the preparation of this Chapter.

The revised view of Miller and Rice concerning the implications of the contrived coincidence of task and sentient group boundaries has been largely ignored by other socio-technical system theorists involved in work organisation, and it does not seem to have influenced the establishment of autonomous group working experiments. It has been noted above that autonomous groups differ in the degree of autonomy they possess (Gulowsen, 1971), and that autonomous group performance may be affected by the motives behind the establishment of the group (Susman, 1970a). The extent to which different types of autonomous group inhibit or facilitate different types or rates of change is, therefore, a possible avenue for future research.

5. It has been argued above that socio-technical system theorists have not dealt in a satisfactory manner with the impact of new production technologies, and automation in particular, upon the organisation and characteristics of work. This is an area in which generalisation is impossible, and another possible

line for further research lies in clarifying the effects of different types of new technologies on work at different levels and in different operating systems in different industries.

6. The technique (or "implementation strategy") of socio-technical system analysis and design is certainly the most sophisticated technique for analysing problem situations and producing job redesign proposals. The 9-step method is used more to stimulate "job design hypotheses" rather than to generate these directly through the analysis itself. The technique, although more formalised than that of Herzberg, is still "ad hoc" in its application in a given enterprise - the final proposals are dependent upon the ingenuity of the job designers. It is not clear in the published case studies how the 9-step analysis actually works in practice; it is more of a heuristic device than a rigorous analytical tool.

Some of these points will be developed further in Section 5 (Resume and Conclusions) below.

4. EPILOGUE

A Synthesis of Techniques : Ray Wild

The two approaches to the design of jobs have now been described. The review has in each case followed the same basic pattern, starting with an outline of the underlying theory and proceeding through the type of job design advocated, the technique of implementation, practical examples or experiments, and published criticism. In a review of this nature, classification of the material into sections is infrequently straightforward, ease of exposition determining the location of some work, partially arbitrary decisions determining the location of others. The work of Professor Ray Wild (now Director of Graduate Studies, Administrative Staff College, Henley, and Head of the Work Research Group there) in this field defies classification, by any criterion, in the foregoing review, but fortunately constitutes a convenient overview and synthesis of some aspects of the work reviewed above which have particular relevance for the sections which follow. Wild and his colleagues (Colin Carnall and David Birchall in particular) carried out an exhaustive review of published accounts of all manner of job redesign studies involving manual workers; it is mainly this work that will be examined here. This work was eventually published in book form (Wild, 1975; Birchall, 1975), but many of the earlier papers will also be cited.

The survey approach was adopted in order to identify basic techniques, objectives, effects and scope of job design. The main objective was to produce a model which would summarise the techniques and objectives of job design. A total of 96 published accounts,

from Britain, Europe and America, were examined and the following categorisation of types of job design change was formulated:

1. rearrangement or replacement of assembly line work.
2. workers given additional responsibility.
3. rotation of jobs.
4. responsibility for additional and different types of work.
5. control of work speed.
6. self-organisation.

This categorisation is completely independent of the theoretical bases of the types of change implemented. It was from this categorisation that the dichotomy between job restructuring and work organisation was developed. Categories 3 and 6 constitute work organisation, the rest are job restructuring. Wild's diagram is shown on page 36 above. (See Wild, 1973; Birchall and Wild, 1973a; Wild, 1974a; and in particular Wild, 1975, pp.46-47 and Appendix A, pp.157-179.)

The survey illustrated the variety of reasons for which job design had been undertaken. A desire to make work more interesting or challenging was often secondary to the solution of other pressing problems such as labour turnover and absenteeism, quality of output and various problems of an economic nature. In the absence of systematic study of job design changes and effects, the work surveyed gave the following list of benefits resulting from job design changes:

1. improved productivity
2. improved quality of work
3. fewer grievances
4. improved worker attitudes

5. better absenteeism and turnover records
6. lower costs. (Wild, 1975, p.50; see also Birchall, 1975, pp. 99-100.)

Among the more intractable problems facing job design attempts were:

- (a) resistance to changes from supervisors;
- (b) increases in responsibility not always followed by changes to the payment system; and
- (c) the preference of some younger workers for jobs requiring little attention.

Forty-six group working experiments were surveyed. (Wild, 1975; Birchall and Wild, 1973b.) Most of these - 70 per cent - involved the establishment of autonomous groups. Birchall and Wild (1973b) describe these as "functional" groups and distinguish them from the establishment of "consultative" groups. The latter are groups that have been established with a once-only or at most intermittent responsibility. Discussing the advantages to the worker from autonomous group working, Wild (1975, p.90) draws heavily on an earlier paper by Emery (1959), and points out four such benefits in particular:

1. increased confidence through recognition of important skills;
2. development of social skills;
3. opportunity to exercise influence and assume a leadership role;
4. group support, encouragement, protection and security.

Miller and Rice (1967) may not entirely agree, but Wild argues that:

".... the existence of functional work groups facilitates the establishment of production targets and standards, provides greater opportunity for work variety and facilitates adaptation to change." (Wild, 1975, p.90.)

In an extended analysis and discussion of the means and ends of job design, Wild (1975) (see also Wild and Birchall, 1973; Birchall, 1975.) suggests a novel breakdown of the job characteristics which the survey as a whole had identified as being desirable. Some characteristics could be described as "attributes" of jobs whereas others could be considered as giving rise to those attributes. Work and job "attributes" include, for example, work variety, use of skill and ability, meaningful and worthwhile work, worker autonomy, and so on. It is the way in which tasks, task relationships, work methods and work organisation are designed which contributes to the existence of these attributes. Does the worker inspect his own materials and set up his own machine, for example; does he perform a "whole" task; is his work mechanically paced; can he select his own work method and does he receive regular information feedback. These are a sample of the facilitating "means" which produce the desirable attributes or "ends". (Wild, 1975, p.58; Wild, 1974b, pp.32-33; Birchall, 1975, p.47.) The value of this distinction, claims Wild, is that it:

".... helps to distinguish between those aspects of jobs which might be manipulated and those job features which changes might affect but which cannot be directly treated."
(Wild, 1975, p.57.)

Towards the end of the book, Wild (1975, Chapter 12) summarises and develops his argument as follows:

First, job design can take the form of job restructuring (enlargement or enrichment) or work organisation (job rotation or self-organisation).

Second, desirable job attributes are created by the identification and manipulation of certain sets of job characteristics.

Third, the creation of autonomous groups is the main form of organisational change the nature and benefits of which are dependent upon the degree of responsibility and autonomy given to the group.

Fourth, job design changes as a whole involve increased worker participation in work planning and control; this is described as "deverticalisation" of organisational hierarchies.

Fifth, Wild outlines a "development policy" for job design which requires a third type of change, in addition to the job restructuring and work organisation changes described. This is "organisational design" which "is introduced in recognition of the fact that neither workers nor production systems exist in isolation in a plant, but as part of a larger organisation." (Wild, 1975, p.152.) Miller and Rice certainly realise this, but those socio-technical theorists who have concerned themselves directly with the design of jobs have concentrated upon the individual operating system (or unit operation) as their basic unit of analysis.

The advantage of this concept is its comprehensiveness; it deals with the operating system and with its environment, and it deals in particular with:

".... the provision of information systems for goal setting, feedback and performance measurement, together with the necessary support systems which ensure the viability and continued existence of the unit."
Wild, 1975, p.152.)

Wild (1975) does not develop the concept of organisational design much further in that book except to suggest that the "ideal" would be ".... the creation of small, integrated and essentially self-contained production units." (p.153.) It is hoped that by now it will be clear why Wild's work in this area has been left until this

stage of the review. The relevance of this work to the thesis advanced in Chapter 3 lies in Wild's contention that organisational design is a component of job design.

Wild's scheme for classifying job design approaches should require little further explanation (See Figure 2.1, p.36). Organisational design may facilitate the establishment of autonomous groups (or "self-organisation") or job rotation; similarly, job rotation and self-organisation facilitate the types of work characteristics produced by job enlargement and job enrichment. This is why work organisation is generally regarded as a more powerful job design technique than the job restructuring approaches.

5. RESUME AND CONCLUSIONS

This summary of the job design literature examined above has four purposes:

1. To identify common components of job design theories.
2. To identify areas of agreement and disagreement between job design theories.
3. To identify problems that job design theories have in common.
4. To suggest an approach to the solution of these problems.

Common Components of Job Design Theories

Job design theories can be regarded as comprising up to four basic components. These are:

- (a) A theory of human motivation that may or may not be based on or coupled with a theory of human nature.
- (b) A model of the situation towards which the theory as a whole directs its prescriptions for change; this could be a model of the individual job, an organisational sub-system or the organisation as a whole.
- (c) A statement, based on component (a), of the types of job characteristic that are considered to be desirable.
- (d) A technique for changing the design of jobs such that they incorporate the characteristics considered to be desirable while maintaining or improving the operation of the situation that is being changed; i.e. a technique for matching components (b) and (c).

These components are discrete in a sense but are interrelated in the

following manner:

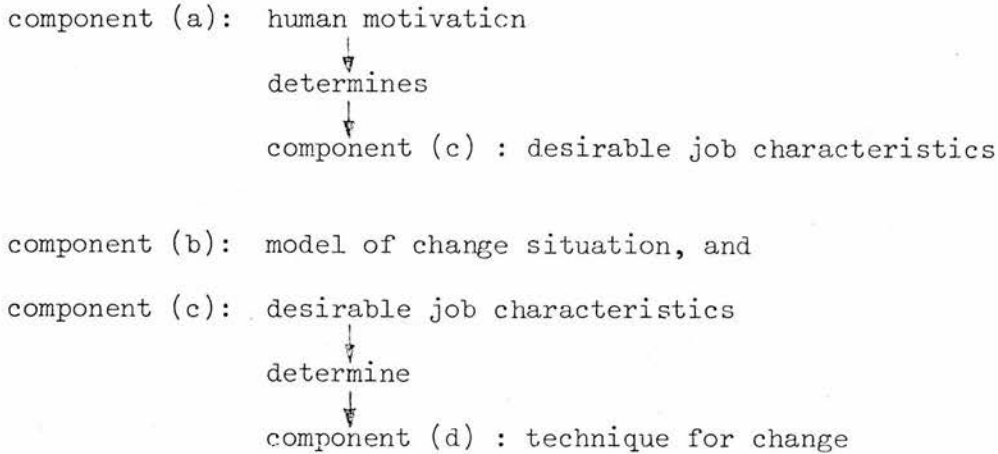


Figure 2.9 summarises the job design theories examined in this Chapter and shows how each theory is made up from these four basic components. The cells in Figure 2.9 have only been filled where the originator or originators of a job design theory have made their views on particular components explicit. This is not meant to imply, for example, that researchers from the Industrial Fatigue Research Board (IFRB) had no conception of human motivation, or that Herzberg has no conception of the types of situation for which he advocates change. These writers simply did not formalise and incorporate whatever ideas they may have had concerning those components into their theories of job design.

It may be seen from Figure 2.9 that only one job design theory incorporates all four basic components. This is the theory of socio-technical system design. It may also be seen that only two job design theories have adopted an explicit model of the situation that they attempt to change. These are the theories of project type organisation and socio-technical system design respectively. On page 230, above, it was claimed that socio-technical system design is arguably the most powerful technique available for redesigning jobs.

Figure 2.9: The basic components of job design theories (job restructuring theories and work organisation theories).
continued overleaf

JOB RESTRUCTURING THEORIES	ORIGIN	MOTIVATION/ HUMAN NATURE MODEL	MODEL OF SITUATION TO BE CHANGED	DESIRABLE JOB CHARACTERISTICS	IMPLEMENTATION TECHNIQUE
Job enlargement	Harding (1931) Walker (1950) MRC Researchers Turner and Lawrence (1965)	None	None	Variety, responsibility, autonomy, interaction, optimum learning time, and elimination of "mass production characteristics", eg: mechanical pacing, repetitiveness, minimum skills use, no choice of work method, product subdivision, use of surface mental attention.	None
Job enrichment	Herzberg (1966, 1968)	Two factor theory of motivation; human "psychological growth" needs.	None	Achievement, recognition, responsibility, advancement, growth in competence, the work itself.	Seven principles of vertical job loading and 10 point check list for arriving at solutions.
Expectancy theory of job design	Hackman and Lawler (1971) Lawler, Hackman and Kaufman (1973)	Expectancy theory of motivation; Maslowian concept of basic human needs.	None	Autonomy, task identity, variety, feedback.	None
WORK ORGANISATION THEORIES	ORIGIN	MOTIVATION/ HUMAN NATURE MODEL	MODEL OF SITUATION TO BE CHANGED	DESIRABLE JOB CHARACTERISTICS	IMPLEMENTATION TECHNIQUE
Job rotation	Vernon, Wyatt and Ogden (1924)	None	None	Variety.	Empirical determination of optimum cycle times.
Project type organisation	Miller and Rice (1967)	Affiliation and security needs; based on psychoanalytic theory,	Socio-technical system model of the organisation; emphasis on adaptation to change.	Group affiliation (ie, "sentience") and security.	None

Figure 2.9 continued: The basic components of job design theories
 (job restructuring theories and work organisation
theories).

WORK ORGANISATION THEORIES (ctd.)	ORIGIN	MOTIVATION/ HUMAN NATURE MODEL	MODEL OF SITUATION TO BE CHANGED	DESIRABLE JOB CHARACTERISTICS	IMPLEMENTATION TECHNIQUE
Socio-technical system design	Emery (1966) Herbst (1966) Davis and Engelstad (1966) van Beinum (1966)	Emphasise needs for affiliation, self-esteem, autonomy, satisfying curiosity, security.	Socio-technical system model of organisation, "unit operations" are basic unit of analysis.	Jobs should provide - <ul style="list-style-type: none"> • reasonably demanding work; • continuous learning; • discrete area of decision making; • social support and recognition; • ability to relate work and social life; • a desirable future. 	Nine step method of socio-technical system analysis; 13 basic hypotheses concerning effective job design; optimum solution is the autonomous group.
Organisational design	Wild (1975)	None	None	Jobs should provide - <ul style="list-style-type: none"> • meaningful and worthwhile work; • variety; • contribution to product utility; • discretion and decision making; • responsibility; • accountability; • promotion prospects; • use of skills and abilities; • social interaction; • autonomy. 	Manipulation of tasks, task relationships, work methods, work organisation, opportunities and "organisational design".

This relative success may be assessed in terms of the technique's ability to change the design of jobs in the required direction. Socio-technical system design utilises all four basic components indicating that it is the most rigorously developed of the job design theories; this is perhaps the principal reason for the comparative success of the theory.

Other job design theories have concentrated on the derivation of desirable job characteristics from theories of human nature and human motivation, and have directed little attention to the problem of putting these prescriptions into practice. One exception to this criticism is the work of Wild (1975) who bases a comprehensive statement of desirable job characteristics (termed "work attributes") on a review of a large number of reported job design projects rather than on a theory of human nature or motivation. Wild has also attempted to develop a framework for the implementation of changes that will produce these desirable work attributes which again is based on a review of job design projects rather than an explicit model of the situation to be changed. In general, however, concentration on the derivation of desirable job characteristics is coupled with a lack of effort devoted to how these characteristics are to be made operational.

Areas of Agreement and Disagreement Between Job Design Theories

There are two main areas of agreement between job design theories. First, the influence of Abraham Maslow's (1943, 1970) theory of a hierarchy of basic human needs dominates the theory of human nature upon which theories of motivation and statements of desirable job characteristics are based. Second, there is wide

agreement over the types of job characteristic that are regarded as desirable. Figure 2.10 summarises these characteristics and indicates the theories that advocate their desirability. Job characteristics that appear to be similar in intent are grouped together in Figure 2.10; thus the claim that jobs should provide "group affiliation" is assumed to be similar in intent to the claims that jobs should provide "social support and recognition" and should provide "opportunities for social interaction". There appears, therefore, to be general agreement over the objectives of job design, over the types of results that should be achieved.

On the other hand there appears to be little agreement upon the technique to be used to implement desired changes. Only three of the job design theories specify a formal method of analysing the situation that is to be changed, and only one of these theories - socio-technical system design - bases this analysis on a model of the situation that is to be changed. It was argued above that a technique for implementing job design changes should rely upon both a statement of the results that should be achieved and a model of the situation that is to be changed. Socio-technical system design, therefore, is the only job design theory that meets this criterion.

The advocated techniques for implementing job design change are not similar. They are:

- | | | |
|-------------------------------|---|---|
| Herzberg | - | 10 point check list for generating ways of implementing 7 principles of vertical job loading. |
| Socio-technical System Design | - | 9-step method of socio-technical system analysis for generating "job design hypotheses". |

DESIRABLE JOB CHARACTERISTICS	ADVOCATED BY
Variety; elimination of repetitiveness.	Job rotation, Job enlargement, Expectancy theory, Organizational design.
Responsibility.	Job enlargement, Job enrichment, Organizational design.
Autonomy; discrete area of decision making; accountability; choice of work method.	Expectancy theory, Socio-technical system design, Job enlargement, Organizational design.
Continuous learning; growth in competence; elimination of minimum skills use.	Job enlargement, Job enrichment, Socio-technical system design.
Task identity; ability to relate work and social life; meaningful, worthwhile work; contribution to product utility; elimination of product sub-division.	Job enlargement, Expectancy theory, Socio-technical system design, Organizational design.
Group membership; opportunity for interaction; social support and recognition.	Job enlargement, Project type organization, Socio-technical system design, Organizational design.
Feedback; recognition.	Job enrichment, Expectancy theory.
Advancement; promotion prospects; desirable future.	Job enrichment, Socio-technical system design, Organizational design.
Use of valued skills and abilities; achievement; reasonably demanding work; use of more than surface mental attention.	Job enlargement, Job enrichment, Socio-technical system design, Organizational design.

Figure 2.10: The principal "desirable job characteristics" and the job design theories that advocate them.

Organisational Design - Manipulation of "means" (task relationships, work organisation, etc.) to generate desired "ends" (10 desirable work attributes).

But these three methods rely on the abilities of the agents of change (managers, consultants, researchers) in a particular setting to identify possible beneficial changes. None of these methods is grounded in a framework of job or organisational analysis that in itself identifies possible job and organisational design changes. There is, therefore, tacit agreement between these methodologies in so far as they are all heuristic devices for assisting the job designer to generate "job design hypotheses" or "vertical loading factors" or "means" that can be manipulated.

There remains a more fundamental disagreement concerning the components that a job design theory should incorporate. It is difficult to argue that a rigorous job design theory can do without one of the four basic components that are identified here, and some of the problems that these theories meet are perhaps due to their lack of one or more theoretical mainstays. This should be borne in mind throughout the section which follows, dealing with the specific problems that job design theories have to face.

Problems that Job Design Theories have in Common

There are at least five problems that job design theories appear to have in common. These are:

- (a) Limited ability to calculate the effects of particular job design changes on other jobs and sections in an organisation.

- (b) Difficulty in making objectives, i.e. statements of desirable job characteristics, operational.
- (c) Difficulty in transferring knowledge of successful types of change from one organisational or technological setting to another.
- (d) Difficulty in implementing job design changes that cater for individual differences.
- (e) Difficulty in calculating the durability of a given change.

These five problems will each be dealt with in turn.

- (a) Limited ability to calculate the effects of particular job design changes on other jobs and sections in an organisation: This problem is illustrated by the difficulty that job restructuring theories of job design have of designing jobs on more than one level of an organisation at a time. The job design experiment of Lawler, Hackman and Kaufman (1973) is an excellent illustration of this (see above, p.145). Job design that goes beyond mere horizontal job enlargement invariably means giving the lowest grade of worker (manual or white-collar) tasks that have previously been performed by supervisors. Job design implies that organisations be "deverticalised" (Wild, 1975) by passing traditional management functions to those performing non-managerial jobs. Determining which managerial functions should be transferred in this way is one of the fundamental questions of job design. Job restructuring theories have paradoxically attempted to answer this question by analysing the content of the job at which the principal change is directed; this explains

the frequent appearance in the literature of job restructuring of sections in papers and books headed "the changing role of the supervisor" or "problems of supervisory resistance".

Job restructuring theories have no method, other than the use of inspired guesswork, of calculating in advance how a given change in job design will affect other jobs and jobs on other hierarchical levels in the organisation. Socio-technical system analysis attempts to circumvent this problem by analysing managerial and non-managerial tasks at the departmental or "operating system" level. This is done through compiling a "table of variance control".

But how the resultant job design changes, such as the establishment of autonomous groups, will affect other levels of management or other operating systems, is indeterminate. Similar criticism applies to the project type organisation advocated by Miller and Rice (1967) and Wild's (1975) organisational design theory.

Job design changes take place at the interface between managerial and non-managerial jobs, and a model of how managerial and non-managerial tasks are interrelated, and of the interrelationships between managerial tasks, is a prerequisite for calculating the ripple effects of particular job design changes on the rest of the organisation.

- (b) Difficulty in making objectives, i.e. statements of desirable job characteristics, operational:

The meaning of, for example, the job characteristic "responsibility" is uniquely determined by the organisational setting to which it is applied and the way in which it is

interpreted by those responsible for the job design changes.

As Wilson (1973) concludes:

".... the efficacy of such approaches has depended hitherto upon the expertise, integrity, and ingenuity of a few exponents who have shown how, within given boundary conditions, it has been possible to increase job satisfaction, responsibility, versatility and other desirable features of occupational life." (Wilson, 1973, p.3.)

The way in which the characteristic "responsibility" is made operational is to make a worker "responsible for" something that he or she was not "responsible for" originally, e.g. inspection of work done. A glance at the job design projects that report increases in responsibility for the workers affected shows the range of interpretations that the term has been given. "Responsibility for" something is clearly a characteristic that can vary widely in degree; the worker can be given "responsibility for" a number of factors that were not part of the job before, e.g.:

inspection
 rectification
 machine set up
 leaving work place without permission
 requisitioning own materials
 hours worked

and so on. How much responsibility should job design aim to give? How is it to be measured? How are two job design experiments, where "responsibility for" parts of the work has been increased, to be compared? Responsibility can vary in different types of degree. Workers may be given one additional "responsibility for", or they may be given six new "responsibilities". Each responsibility, on the other hand may differ to the extent that supervision is maintained; supervision may be removed entirely, it may be carried out at

regular or random intervals. Therefore, bald statements to the effect that job design changes have led to workers being given increased responsibility do not mean a great deal.

The other job characteristics that are considered to be desirable attract the same criticism; there must be an infinity of ways, for example, in which the "variety" of a job can be increased. The establishment of autonomous work groups also meets this problem. The arguments of Gulowsen (1971) and Banks (1974), concerning the differences in degrees of autonomy between groups, have been noted above. And as Wild (1975) suggests, the degree of autonomy or capacity for self organisation that a group of workers possesses may determine the extent to which other desirable job characteristics are present.

This difficulty in making job design objectives operational can also be seen in the results of certain job restructuring projects that have produced autonomous group working solutions. Paul and Robertson (1970) describe two such job enrichment projects, and these were discussed at some length above (see pp.114-116). A number of other job enrichment projects that adopted group working solutions were also mentioned (see p.116 above). Admirable though these solutions may be, they reach beyond the limitations of the theory that inspired them. It has also been noted that Herzberg himself never intended job enrichment to be used in this way. Wild's (1975) categorisation of reported job design projects also reflects this confusion to a certain extent. He classifies twice a project reported by Wilkinson (1970) - as a group

working exercise (Wild, 1975, p.215) and as an example of a job restructuring exercise in which "workers are given additional responsibility" (Wild, 1975, p.167).

These difficulties arise in part because the stated objectives of job design theories are heuristic devices - like the techniques used to implement them. They are not tied in any way to a theoretical framework that can be used to direct the process of change.

- (c) Difficulty in transferring knowledge of successful types of change from one organisational or technological setting to another:

This problem was recognised some time ago by researchers at the Tavistock Institute. (See Emery, 1966 and p.208 above.) Job design changes that have proved successful in, for example, a chemicals processing plant are difficult to state in terms that make them directly applicable to, say, clerks in an insurance office. Job design objectives and the techniques for implementing them are heuristic devices rather than theoretical frameworks of analysis and change. Job design changes that are worked out in particular organisational and technological settings tend, therefore, to be bound to the settings in which they originate. Except in the most general of terms, each job design application must start afresh and solutions that are worked out are not cumulative. The job designer cannot compile a toolkit of solutions over a number of applications.

- (d) Difficulty in implementing job design changes that cater for individual differences:

If a group of workers as a whole rejects a proposed job design change, that change will invariably not take place. But where there is general acceptance of change, there are always likely to be some who will find that the new duties and "responsibilities" bring fatigue, stress, frustration and anxiety. There may on the other hand be some who continue to find their jobs too restricting. This also applies to the autonomous group solution, except perhaps to the extent that the group has "responsibility for" its own internal task allocation and choice of work methods. Job design changes, therefore, generally impose a standard solution upon a more or less heterogeneous work force.

- (e) Difficulty in calculating the durability of a given change:

Penzer (1973; see p.96 above) points out that people who respond positively to job enrichment tend to become frustrated once the novelty has worn off and no further enrichment is forthcoming. Jenkins (1974; see p.97 above) also notes this problem. The beneficial effects of job design changes may, therefore, be short lived. This is perhaps one way in which the job designer can ensure that his skills will be required again at some future date.

The implementation of job design imposes static organisational solutions that may be approximately "right" at the time of implementation but which are liable to be overtaken by developments - organisational, technological and

human. The project type organisation advocated by Miller and Rice (1967; see above, pp.167-173) attempts to overcome this problem, but is not really a job design theory since it is not directed specifically at change of job content. It is a prescription for organisational design that is likely to affect the design of jobs, although Miller and Rice do not explore this possibility. Their theory is more of a conceptual guide than a framework of organisational analysis and change. Job design theories do not appear to be capable of generating jobs or organisational design solutions that have a built-in capacity to react and adapt to change. Autonomous groups may, depending upon their degree of autonomy, have some capacity to cope with change, but Miller and Rice (1967) have suggested that this capacity may be severely limited where change implies alteration in the composition of the group or threatens its very existence.

An Approach to the Solution of These Problems

These five problems seem to be symptoms of the same underlying weakness of job design theories - the difficulty in translating prescription into action. It was argued above that implementation of job design depends upon two components of the theory - a statement of the objectives that are to be achieved, and a model of the situation that is to be changed. An adequate model of the situation to be changed should indicate, therefore, how the desired changes can be made operational. None of the job design theories fulfils this criterion very well. It has been shown above that there is general agreement about the objectives of job design, i.e.

about the kinds of job design changes that are considered to be desirable. The key to the solution of this problem of translating prescription into action appears to lie in the formulation of an appropriate model of the situation that is to be changed. But what attributes should such a model possess?

One of the major arguments of this thesis is that an appropriate model for a job design theory should possess at least the following three attributes:

- (a) The model should take the organisation as a whole as the basic unit of analysis, and not some segment of the organisation.
- (b) The model should be a normative one showing how an organisation should function, and not a framework for a descriptive analysis of how particular organisations function.
- (c) The model should be a general one, i.e. applicable to any type of organisation and not restricted to a particular type of work or to a particular technology.

The reasons for suggesting that an appropriate model should possess these attributes will be given for each attribute in turn.

- (a) The model should take the organisation as a whole as the basic unit of analysis:

Two of the five main problems discussed above arise when job design theory does not regard the organisation as a whole as the unit of analysis. First, there is the difficulty of calculating the effects of particular job design changes on other jobs and sections in an organisation. Second, there

is the related difficulty of making job design objectives operational. Job design generally takes place at the interface between managerial and non-managerial jobs. The problem of job design is essentially one of allocating managerial tasks to those who perform non-managerial tasks. This is difficult if the job designer is not aware of the totality of tasks - managerial and non-managerial - that are available to allocate to members of the organisation, and the relationships between these tasks. Job design theories that take the individual job or the organisational sub-system as the basic unit of analysis are not capable of adequately expressing the complete range of possibilities in the situation that is to be changed.

Three job design theories adopt on the surface a model of the organisation as a whole. These are:

- project type organisation - Miller and Rice
- socio-technical system design - Emery et al
- organisational design - Wild

The approach of Miller and Rice is not a true job design theory, as noted above; it is a prescription for organisational design based on a model that is more of a conceptual guide to the analysis of organisation than a detailed framework for organisational analysis and change. Socio-technical system design is based upon an organisational model but the approach to the implementation of the theory is to split the organisation under analysis into operating systems which are dealt with separately. The organisational design approach advocated by Wild does not in fact incorporate

an organisational model but concentrates on showing how certain organisational characteristics (such as tasks, task relationships, work methods, work organisation etc.) can be manipulated to produce the desired objectives. Wild (1975) gives little indication of how this manipulation is related to organisational design (see p.241, above) but merely states that organisational design is a necessary approach. Wild's (1975) recommendation that an approach to the design of jobs should take account of organisational design is here accepted. The socio-technical system model of organisation is inappropriate for the design of jobs because in practice it does not possess the attribute of regarding the organisation as a whole as the basic unit of analysis.

- (b) The model should be a normative one showing how an organisation should function:

The design of jobs and the design of organisations are closely interrelated as argued above. Job and organisational design attempt to prescribe how organisations should function and what characteristics jobs should possess. These overall objectives imply that job design theory should be based on normative models rather than on descriptive analyses.

Organisational change of any kind that is not based on a model of how the organisation should function - i.e. a normative model - can only be directed by the opinions, assumptions and prejudices of those who are implementing the change. The techniques that job design theories use to implement their recommendations are heuristic; they are not

based on organisational models that are themselves bases for a framework of organisational analysis and change.

It should be possible to state a model of organisational functioning in such terms that the model is not outdated by developments; there should be some level of generality that expresses unchanging prerequisites of effective organisational functioning. Organisational change in the direction of these prerequisites, whatever they may be, will, therefore, not meet with the difficulty of calculating the durability of particular changes as discussed above. Change in the required direction will always be desirable. The problem, then, is to formulate a normative model in sufficiently general terms such that it is still appropriate to the task of job and organisational design.

- (c) The model should be a general one, i.e. applicable to any type of organisation:

Investigation and dissemination of the results of job design changes is hindered to the extent that job design prescriptions and solutions are applicable only to certain types of work or in certain types of organisation. A job design theory that is based on a general model of organisation would to some extent solve the problem of transferring job design knowledge from one organisational setting to another. A model that will apply to a chemicals processing plant and to an insurance office must rely on terms that express types of task - managerial and non-managerial - rather than specific task content. The model should make no distinction between the methods of

performing certain types of task, i.e. as to whether they should be performed by individuals, groups, machinery, or computers.

Job design theory should incorporate a model of the situation at which change is directed; the attributes that such a model should possess and the reasons for suggesting these attributes have now been presented. An attempt has been made to indicate how a model that possesses these attributes will to some extent solve the problems that current job design theories face. The following chapter, Chapter 3, describes the development of a model that possesses the three attributes discussed - a general, normative model of organisational functioning.

CHAPTER 3:

SYSTEMS, CYBERNETICS AND PRODUCTION

CONTROL.

The Aim of this Chapter

It was argued, at the end of Chapter 2 above, that existing techniques for achieving job design objectives are heuristic in nature and are based on partial, descriptive models of organisational functioning. It was further argued that a model appropriate for the design of jobs should possess at least the following three characteristics:

- (a) It should be a model of an organisation as a whole and not merely a model of part of an organisation. The model should thus be capable of expressing a breakdown of the "total task"* of the organisation, identifying the totality of individual tasks that are required for the effective functioning of the organisation.
- (b) It should be a normative rather than a descriptive model; that is, it should reflect the way in which an organisation must function if it is to be effective, rather than provide a description of how any particular organisation does in fact function.
- (c) It should be a general model, not bound to one organisational type or technological setting.

The aim of this Chapter is to develop a model that possesses these three characteristics.

Job design that goes beyond horizontal enlargement involves the reallocation of managerial tasks to those who perform non-managerial

* This is a term used by Burns and Stalker (1961, p.97).

tasks. One obvious starting point for job design is, therefore, an examination of the managerial function and in particular of the managerial tasks that are available for reallocation. In a limited sense, the nature of specific non-managerial tasks is determined by the nature of the business that an organisation conducts and the technology that it uses. What this does not determine is the way in which tasks are combined into jobs, the methods of performing specific tasks, and the relationships between workers who perform these tasks. But given the nature of the organisation's business, the specific non-managerial tasks that have to be performed in the conduct of that business are comparatively easy to identify. The problem lies in identifying the managerial tasks that must be performed. Job design is a process by which workers are given supervisory/managerial tasks to perform and a job design theory should ideally be capable of identifying the tasks that make up the management function, and showing how these could be reallocated to workers.

The question that is really being posed here is "what is the nature of management?" Now a multitude of writers have attempted to deal with this question and it is not the intention here to review their answers. The definition that forms the foundation of this Chapter (and of this thesis as a whole) is that management is the organisational function concerned with information processing and control. The term "management" is thus used here to refer to an organisational function and not to the individuals who have been assigned to carry it out. The use of this definition may be justified from two points of view. First, this is a widely used view of the nature of management. Second, it has been suggested

that organisational control systems are a prime determinant of organisation structure. These two points of view are examined in more detail in the following two sections.

Management, Information Processing and Control

The view that management is a process of information processing and control is by no means new and can be detected in the writings of "classical" management theorists. Brech's (1965) definition of management, for example, ascribes four elements to the process: planning, coordination, motivation and control. Brech describes how these four elements are related to each other in a "feedback cycle" (Brech, 1965, p.14). At the planning stage of the process, objectives are set and the means of achieving them determined. The motivation and coordination stages of the process are concerned respectively with stimulating loyalty and satisfactory performance in employees and with maintaining harmony between the various work activities of the organisation. The control stage of the process, for Brech, concerns checking actual performance against the objectives that were set in order to ensure that adequate progress has been made. Information about the success or otherwise of the operations of the organisation is then fed back to the subsequent planning stage of the process so that improvements may be made to overall performance in the future. This completes Brech's "feedback cycle". But the entire process - set objectives, operate, measure performance against objectives, review objectives, operate, and so on - may be regarded as a control process. "Control" is not really a discrete part of the management process, it is the very nature of the process as a whole.

This view is reflected in the following statement of Bavelas and Barrett (1951):

"It is entirely possible to view an organisation as an elaborate system for gathering, evaluating, recombining and disseminating information." (p.59 in Yukl and Wexley, 1971.)

The degree to which an organisation is effective in processing information, they argue, determines the effectiveness of the organisation as a whole. Information processing is thus a fundamental rather than a derived aspect of organisation:

".... it is the essence of organised activity and the basic process out of which all other functions derive. The goals an organisation selects, the methods it applies, the effectiveness with which it improves its own procedures - all of these things hinge upon the quality and availability of the information in the system." (Bavelas and Barrett, 1951, p.59 in Yukl and Wexley, 1971.)

The division between non-managerial and managerial work (i.e. between manual and intellectual work) can be regarded as a division between the operations of an organisation and the control of those operations. A number of theorists have made use of this dichotomy. Ansoff (1969b), for example, develops a "theoretical conception of the firm" (p.13) which is based on the distinction between what he terms the "logistic process" and the "management process" respectively. This distinction is illustrated in Figure 3.1. The logistic process concerns the conversion of resources (labour, materials, money, information) into products or services. The management process on the other hand is concerned with information processing and control:

"The inputs to the [management] process are the perceived needs for modification of the logistic process; the outputs are action instructions for changing or re-directing the logistic process." (Ansoff, 1969b, p.13.)

The management process controls the logistic process by measuring its

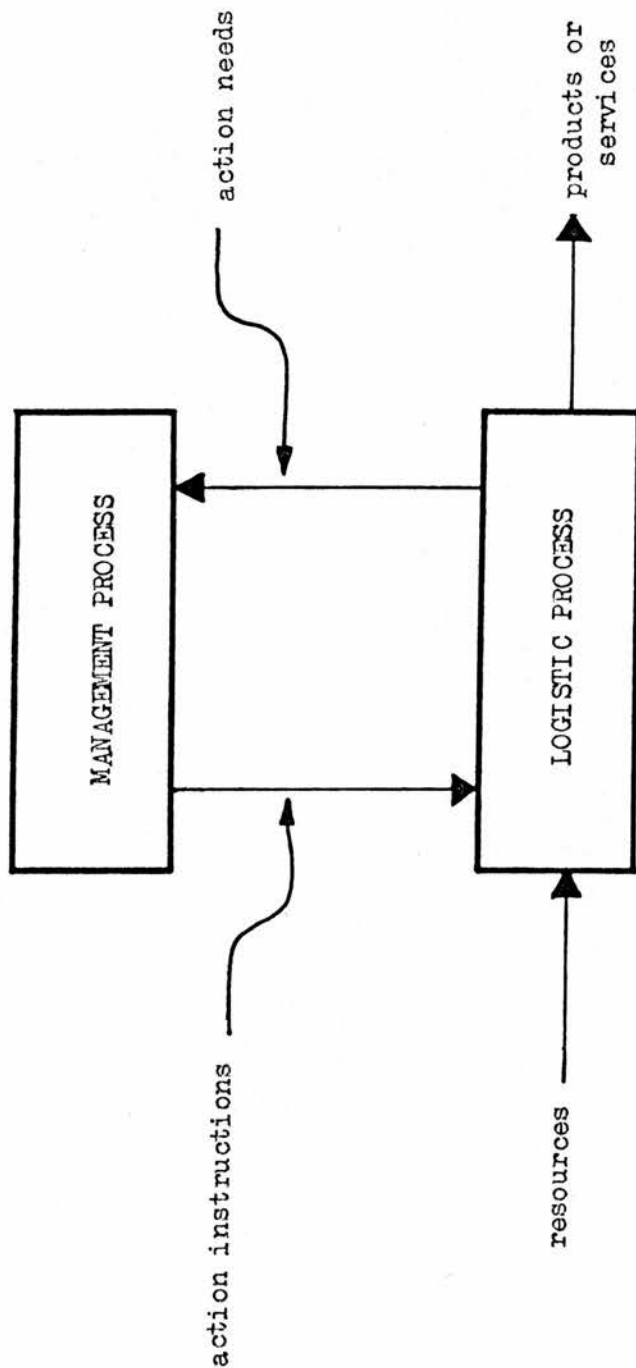


Figure 3.1: Ansoff's basic model of the firm; Ansoff, 1969b, p.14.

performance and deciding how to improve or maintain that performance as necessary. The arrows that are labelled "action needs" and "action instructions" in Ansoff's model represent the flows of information about the logistic process and about management process decisions respectively.

J.G. Miller (1972) draws the same distinction, between what he terms "matter-energy processing" and "information processing" organisational sub-systems. Miller's objective is to derive a taxonomy of organisation structure that will "... provide a workable scheme by which all organisations, regardless of their structures and particular suprasystem functions, can be related to each other and upon which generalisations and models can be based." (Miller, 1972, p.13.) Reeves, Turner and Woodward (1970) differentiate between "production technology" and the "administrative system" (see p.8); Reeves and Woodward (1970) distinguish the "executive system" from the "design and programming system" (p.47). These distinctions are of course similar to that made by (E.J.) Miller and Rice (1967) who divide the enterprise into operating systems and managing systems. They analyse operating systems in terms of their import - conversion - export processes and argue that managing systems can be analysed in exactly the same way. Boundary control, the fundamental management task, is a sub-system which imports measurements and other data relevant to performance, converts this information by comparing the measurements with performance standards, and exports decisions to stop, continue or modify the process that is being controlled.

The relationship between an organisation's operations and its management has thus been described in a number of different

terms. The terminology that appears to be most appropriate, however, are "operating system" and "information processing system" for what Ansoff has called the logistic and the management process respectively. These terms are suitably descriptive while maintaining a generality of application.

The design of operating system jobs has tended to rely on studies either of the individual job or of the operating system itself. But job design takes place at the interface between the operating system and the information processing system and the nature of the latter cannot, therefore, be ignored.

Organisation Structure and Control

A second reason for regarding management as an information processing and control function lies in the hypothesised relationship between the control system and the structure of an organisation. The late Joan Woodward's celebrated study of the organisation structures of firms in South Essex claimed to have established a causal link between the technology employed in production and certain aspects of organisational structure and behaviour (Woodward, 1965). Woodward's results were based on a typology of manufacturing technology ranging on a scale of complexity from unit and small batch production, through medium to large batch production and component assembly, to continuous process production. Organisation structure (e.g. levels of authority, ratio of supervisory to non-supervisory staff) and certain aspects of organisational behaviour (e.g. managerial attitudes, tone of industrial relations) appeared to be related to production technology in a more consistent and predictable way at the extremes of the scale; but firms in the

intermediate points (i.e. medium to large batch production and component assembly) proved more difficult to analyse. Woodward's research group thus turned its attention to firms in the centre of the scale of technological complexity in an attempt to refine their analysis of technological variables to a point where differences in organisational structure and behaviour in this group of firms could be more satisfactorily explained. (See Woodward, 1970a.)

Recognising that in many instances the technology (i.e. the tools, machinery and other equipment) used in this type of production is not rigidly determined by the task in hand and that management can generally exercise considerable choice in the matter, the research team were led to study the ways in which manufacturing tasks are controlled, and hence to analyse the relationship between technology and control.

Considerable problems arose in measuring and classifying technological variables in a way that would make valid inter-firm comparisons possible. A number of avenues were followed without success, but one "common thread" did appear to run through most of the work that had been done. This common thread was the concept of variety. Production tasks differ in the amounts of variety that they are capable of generating and this appeared to be the one underlying variable which could explain differences in patterns of behaviour, not only between firms in the centre of the scale of technological complexity, but across the whole range:

"The variety might depend upon the nature of the product, the nature of the market or the nature of the manufacturing processes themselves, but looking on it from the point of view of the constraints in the work environment, variety, whatever its cause, seemed to have similar effects on patterns of behaviour." (Rackham and Woodward, 1970, p.30. Cybernetic theory uses the term "variety" in a rather different way, and this is defined below.)

In other words, the "technical system" creates variety, which leads to uncertainty and unpredictability, which the "social system" then has to cope with. (These are the terms used by the research group.) The relationship between technology and organisational structure and behaviour, therefore, is affected by the degree of uncertainty and unpredictability in the production task (Rackham and Woodward, 1970, p.35). This conclusion produced the hypothesis that "... organisational structure is not so much a function of technology as a function of the control system..." (Reeves and Woodward, 1970, p.37). Where production technology is the main determinant of the control system, as is likely to be the case in both unit and continuous process production, organisational structure and behaviour tend to be more consistent and predictable. Where there is a choice of technology for performing the manufacturing operations, there will also be a choice of control systems, and organisational structure and behaviour become less consistent and predictable. Management in batch production thus has a wider choice of control procedures to adopt, and the control system in this type of firm is more likely to reflect the attitudes and beliefs of top management than to be determined by technology (Woodward, 1970a, p.xi). Control, therefore, is an intervening variable affecting the link between technology and organisational structure and behaviour. This conclusion helps to explain the anomalies in the results of the original South Essex study concerning the firms in the centre of the scale of technological complexity.

The research of Woodward et al thus suggests that there are identifiable relationships between (a) the technology of an operating system, (b) the nature of the information processing system, and

(c) organisational structure and behaviour. In medium and large batch production and in component assembly, the information processing system (i.e. the control system) is not rigidly determined by technology and the opposite may in certain instances be true. The dependence of job and organisational design upon the nature of the information processing system is, therefore, considerable.

Cybernetics and Control

".... if we wish to think about control in the firm we should use a control system as a model."
(Beer, 1972, p.112.)

In thinking about management as an information processing and control function, it is natural to turn to the field of cybernetics for assistance. Cybernetics is the science of "control and communication in the animal and the machine" (Weiner, 1947). The name is derived from the Greek "kybernētiquē", and occurs frequently in the work of Plato, meaning "the art of steersmanship". It was also used by Ampère (in 1834) to describe the study of means of government; the French translation is "cybernétique". Unaware of these earlier uses of the word the American mathematician Norbert Wiener believed that he had coined the word cybernetics, giving it the meaning cited above. His choice of word was influenced by James Watt's mechanical regulator, called a "governor", and by Maxwell's theoretical analysis of "The Theory of Governors" (published in 1868). (See Guilbaud, 1959.)

Cybernetics is concerned with control of systems, animate and inanimate. The central hypothesis of cybernetics is that the basic nature of the process of control is independent of the type of system being controlled. Whether the system is animate or inanimate, social

or economic, the nature of its control may be described and analysed in the same terms.

Development of systems and cybernetic theories has been influenced by the realisation of the enormous complexity of apparently simple systems. For example, if the relationships between each pair of a group of seven people are to be described as either "friendly" or "hostile", there will be a total of 1,000,000,000,000 different possible states that their relationships can adopt.* The cybernetic term for this complexity is "variety" which is defined as the number of distinct elements (in the above example, states of relationships) in the system. This affects system control in a fundamental way; the controller must be able to deal with any state that the system is capable of entering, if control is to be effective. In other words, the controller must be able to generate as much variety as the system being controlled; "... only variety can destroy variety" (Ashby, 1956, p.207; see also Beer, 1959, p.50). This has been called by Ashby "The Law of Requisite Variety".

Stafford Beer (1959) suggests that systems can be classified (a) as either simple, complex or exceedingly complex, and (b) as either deterministic or probabilistic. Cybernetics then is concerned with control in exceedingly complex, probabilistic systems.

* There are 7 people, therefore there are $n(n-1) = 42$ relationships to consider. Each relationship can be in one of 2 possible states, friendly or hostile, so the total number of possible states of their relationships is -

$$2^{42} > 10^{12.5} > 1,000,000,000,000.$$

The popular notion of control, involving the use of force or coercion, has no place in cybernetic theory which deals rather with the arrangements whereby systems move towards optimum performance through self regulation. Certain natural systems - the human body and higher forms of animal life are examples - are able to modify their behaviour on the basis of past experience, either to maintain or to improve conditions that are favourable to them in some respect. In nature, control mechanisms are "homeostatic" rather than "autocratic" and cybernetics, therefore, deals with the former.

A homeostat is a device that holds a variable within desired limits by a self regulatory mechanism. The homeostat incorporates a measuring device which activates a compensatory mechanism that moves a variable back towards the required level as it begins to move away from this level. Control in the homeostat operates automatically as the system begins to go out of control. The measuring device monitors the changing level of the variable under control and the output or performance of the system is fed back to the measuring device and so operates the compensatory mechanism when necessary. "Feedback", therefore, is the basis of self regulation. This arrangement is illustrated in Figure 3.2 which indicates the four basic components of the process of control:

1. a receptor which continuously measures performance;
2. a control apparatus or comparator which determines the difference between actual and desired performance;
3. an effector which rectifies deviations from desired performance;
4. feedback, of the system's output or performance, which informs the receptor of the results of the action taken by the effector.

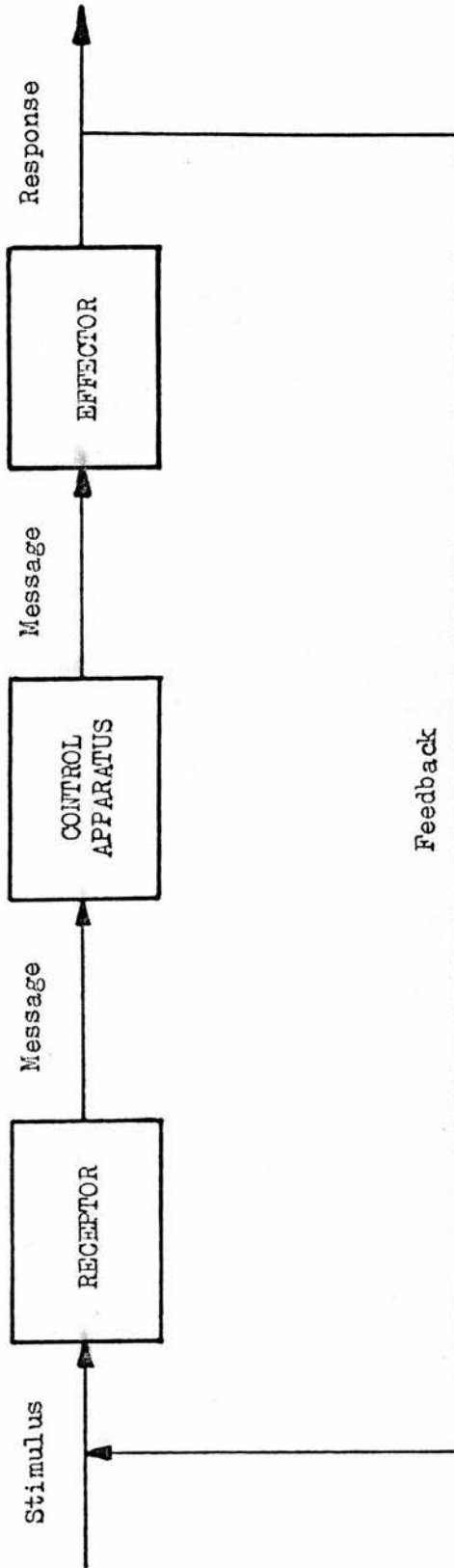


Figure 3.2: A simple feedback mechanism; see von Bertalanffy, 1968, p.42.

The arrows in Figure 3.2 represent information flows - messages about the current state of the variable under control, messages about the action required to restore it to the norm, messages about how successful this action has been, and so on. The homeostat (thermostat) that controls domestic heating systems operates in precisely this manner. Feedback does not manifest itself in the domestic thermostat in the form of wires or tubes or other mechanical contrivances; the arrow labelled "feedback" in Figure 3.2 represents the concept of using information about a system's output to affect subsequent outputs. With the domestic thermostat it is the temperature of the air in the house that is both output and input of the system.

Feedback control is not switched on and off by some external agency. It is activated by the system itself as it goes out of control. A further fundamental characteristic of feedback control is that it acts not against a given disturbance or set of disturbances to the system but against all manner of disturbances including those whose causes are unknown and those which could not have been predicted by the system designer. Thus:

"Arrangements are not made to record every possible state of the system and every best answer to every state. Arrangements are instead made to ensure that the system will be able to find, or to learn to find, the answers to problems it is set." (Beer, 1966, p.302.)

Systems that have this capability are called "ultrastable systems" (Beer, 1966, p.291; the concept is Ashby's, 1956). An ultrastable system can return to its normal state of functioning after having been disturbed in a manner not predicted by its designer. The domestic thermostat can restore the house temperature regardless of what has altered it. (Catastrophe aside, that is: it could

clearly not cope with another ice age or with the house burning down, although it could cope with someone bringing blocks of ice into the house, or with an indoor barbecue.)

Figure 3.2 illustrates the basic, general cybernetic concept of control. It can be used to describe and analyse a variety of control mechanisms in mechanical, organic, social and economic systems (see for example the discussion in Weiner, 1950). The province of cybernetics may now be defined as including exceedingly complex, probabilistic systems of a self regulating nature.

Management Cybernetics

A number of writers have suggested that cybernetic models of control can be usefully applied to the study of (usually large) organisations. This view has led to the development of what is now called "management cybernetics" (George, 1971, Chapter 10, and Beer, 1959, 1966 and 1972). Examples of the use of cybernetic models of organisation include:

1. The analysis of internal communication networks (Churchman, Ackoff and Arnoff, 1957).
2. The analysis of organisational adaptation to change (Cadwallader, 1959).
3. The analysis of the effect of information feedbacks on the pursuit of specific organisational objectives (Haberstroh, 1960).

Cadwallader further claims that a cybernetic approach to organisational modelling focuses attention on a number of areas:

- "1. the quantity and variety of information in the system;
2. the structure of the communication network;
3. the pattern of the subsystems within the whole;
4. the number, location and function of negative feedback loops in the system and the amount of time-lag in them;
5. the nature of the system's memory facility;
6. the operating rules or programme determining the system's structure and behavior." (Cadwallader, 1959, p.439.)

Miller and Rice (1967) found cybernetic models of organisational control useful in analysing alterations in the power and authority structure of a steel works faced with changing environmental conditions. Changes in the market for steel rendered the company strategy of maximising production inappropriate and led to the introduction of two new strategies - maximising customer satisfaction and conserving resources. These new strategies, argue Miller and Rice, each required a different mode of control. The strategy of resource conservation, for example, required a "segmented control system", illustrated in Figure 3.3. The higher order system is here responsible for overall review of performance standards while the lower order unit control systems measure performance, compare this with the standard, and make any necessary alterations to the operation. The strategy of maximising customer satisfaction, on the other hand, required an "integrated cybernetic model" of control, illustrated in Figure 3.4. Here each unit is not permitted to concentrate on attainment of its own standards but the enterprise

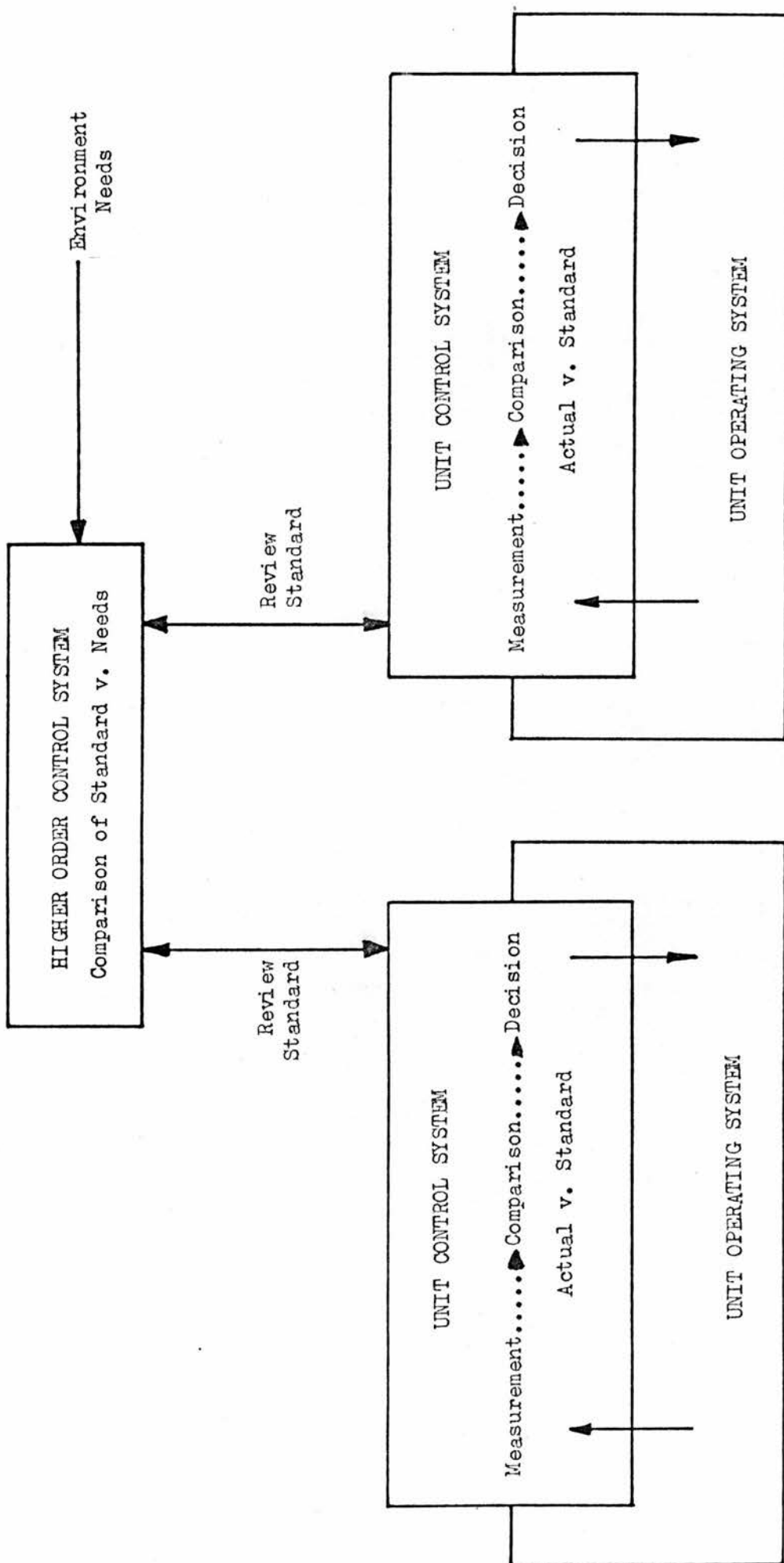


Figure 3.3: Segmented control system; Miller and Rice, 1967, p.240.

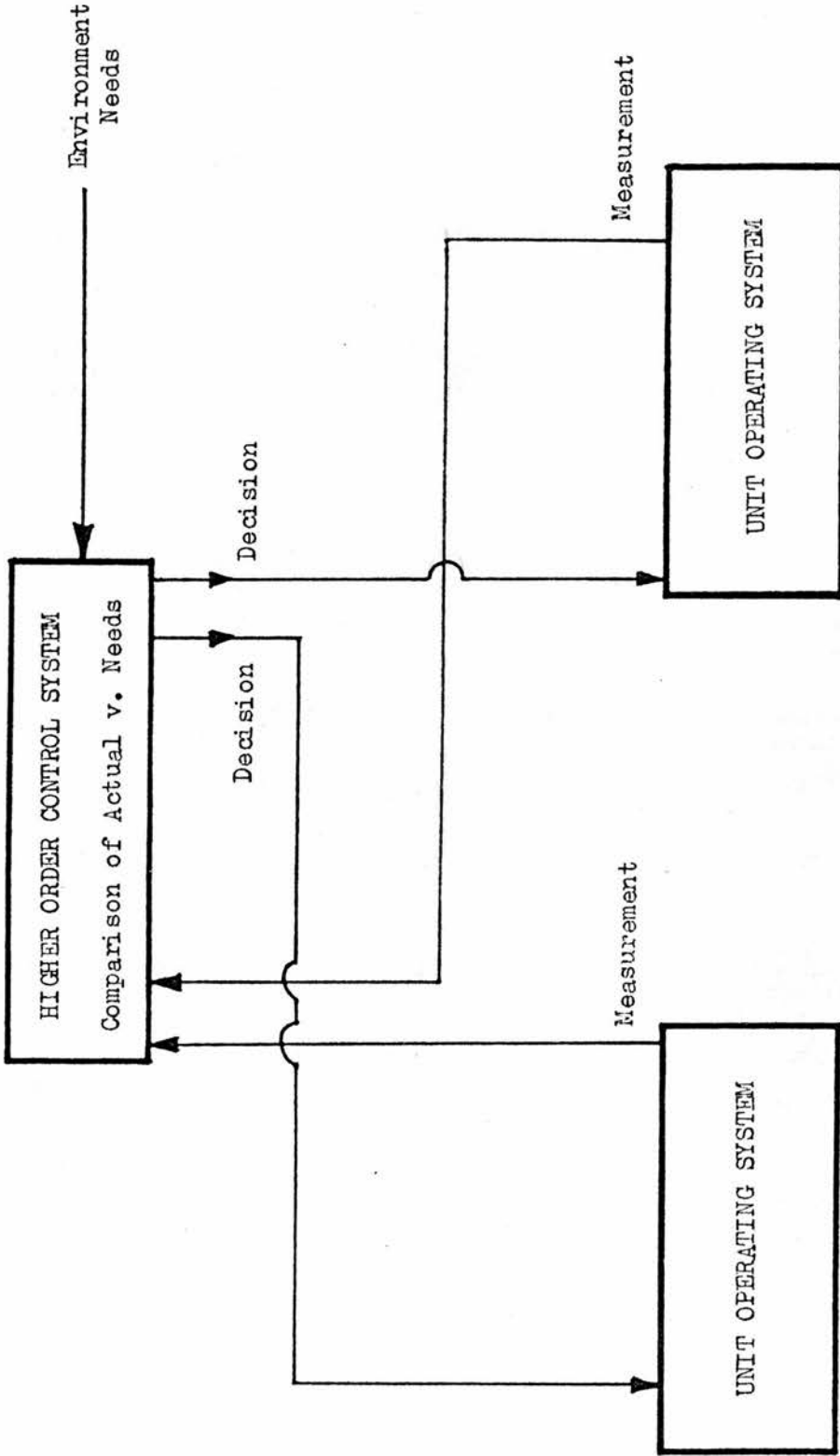


Figure 3.4: Integrated cybernetic control model; Miller and Rice, 1967, p.241.

as a whole is related to the changing external environment. Both these models are elaborations of the basic feedback concept illustrated in Figure 3.2 above.

The application of cybernetics to the study of the management function is not explored further by Miller and Rice, but this topic has been pursued in some depth and over a prolonged period by Stafford Beer (now at the University of Manchester Business School). An attempt is made here to summarise his theory of management cybernetics. The sources that are used (he has published extensively) are his three main books on the subject: "Cybernetics and Management" (Beer, 1959), "Decision and Control" (Beer, 1966) and "Brain of the Firm" (Beer, 1972). Cybernetics has been defined as the study of exceedingly complex, probabilistic, self regulating systems. Industrial and social systems, however, tend not to meet all these criteria, but it is Beer's contention that such systems, in order to be effective, should be designed as cybernetic systems. His main concern lies with describing how this can be done (see Beer, 1959, p.23).

Natural systems are frequently self regulating; they teach themselves to operate in the most effective way through time. Beer thus states that:

"It is a primary aim of industrial cybernetics to harness this ability of a system to teach itself optimum behaviour. To do it, however, we must know how to design the system as a machine - for - teaching - itself. There must be exactly the right flow of information in the right places; rich interconnectivity; facilities for the growth of feedbacks and so on." (Beer, 1959, p.57.)

The problem of control lies in coping with variety, and self regulation and variety reduction both require information. It is information that "kills" variety and cybernetic systems are usually

systems for handling information. Effective control cannot be achieved by attempting to enumerate all the possible states of a system, or even the most important ones, because the number of such states is enormous. Any system of organisation management that does not take this into account will be highly inefficient. In Beer's words, "... cybernetics is the science of control, management is the profession of control" (Beer, 1966, p.239).

The basic nature of the control process is common to all types of system. Beer describes how "... cybernetics is actually done by comparing models of complex systems with each other and seeking the control features which appear common to them all" (Beer, 1972, p.112). By looking at an example of control which has been shown to be eminently successful, argues Beer, one gains insight into the structure of effective control. Beer chooses to consider the human nervous system as an example of successful control - of "good management par excellence" (Beer, 1972, p.115). Comparing a model of the way in which the human body is organised and controlled with the management of an enterprise, should indicate the deficiencies of the latter and suggest ways of overcoming them. Beer's model of the nervous system comprises a five level hierarchy of "control echelons" that are serially arranged on a "vertical command axis" that represents the spinal column. This division into five levels Beer admits, is arbitrary (1972, p.128), but he claims that this seems to reflect the major functional differences that are involved. Beer's model is shown in Figure 3.5.

Beer contends that this control hierarchy is a fairly accurate analogue of a firm's management hierarchy and that the functional differentiation between the components of the nervous system is

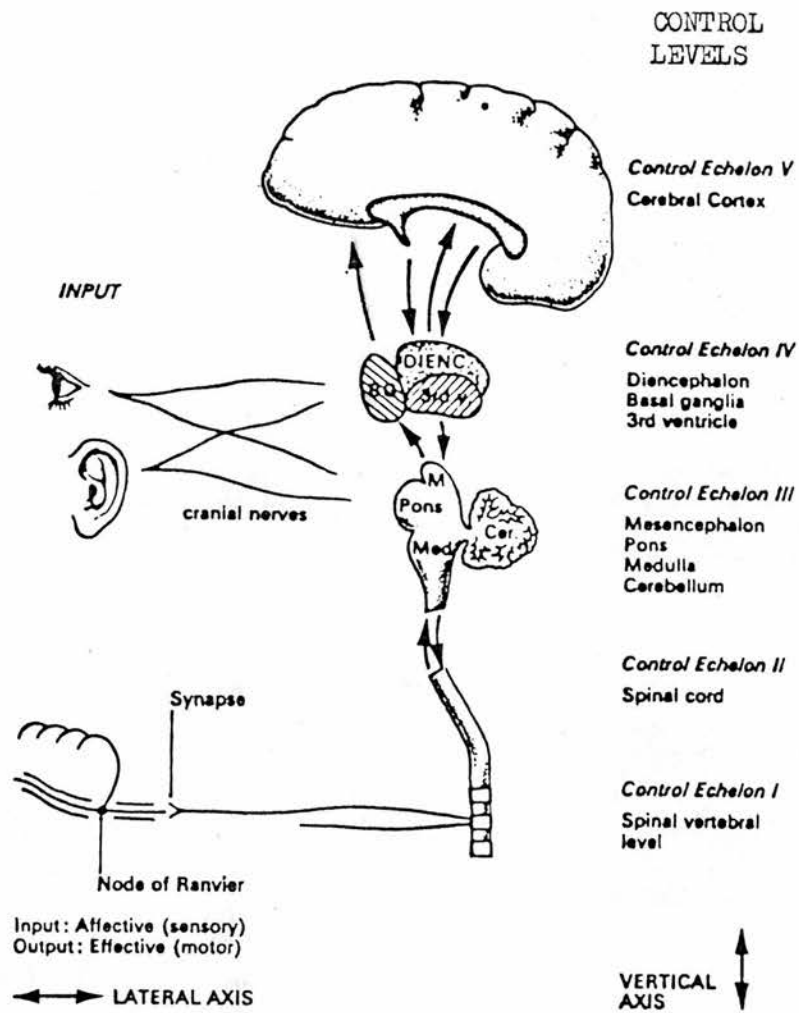


Figure 3.5: The human nervous system as a five tier hierarchy of control; Beer, 1972, p.129.

reflected in the functional differentiation between levels of management. Control echelon 1 corresponds to first line supervision; control echelon 5 corresponds to the Board of Directors. In the body, echelon 5 is the cerebral cortex and this explains the title of Beer's "Brain of the Firm" (1972).

Beer is concerned with analysing existing management structure and with showing how it may be made to work more effectively. The criterion of success (given that the ultimate goal is organisational survival) is effectiveness of information handling or effectiveness of control. This is a descriptive model; Beer states that "... it is contended that all viable organisations are really like this already" (1972, p.198). Beer's model is not, therefore, appropriate for the design of jobs. In fact his model provides a rationale for existing hierarchical organisation structures. To reject this model of the human nervous system as a prototype of effective organisational control is not to reject the fundamental cybernetic hypothesis that the process of control is invariable.

Models of Production Control

A number of writers have taken the simple feedback mechanism of Figure 3.2 as a building block for models of production control. One example is the "enterprise model" developed by Boyd (1966) and shown in Figure 3.6. Boyd's enterprise model distinguishes three levels of control (as opposed to Beer's five levels). Each level of control determines the activities of the level below, and this model thus represents a three level hierarchy of control. Strategic planning, in Boyd's model, deals with overall directional control of the enterprise and works on an annual time scale. Tactical

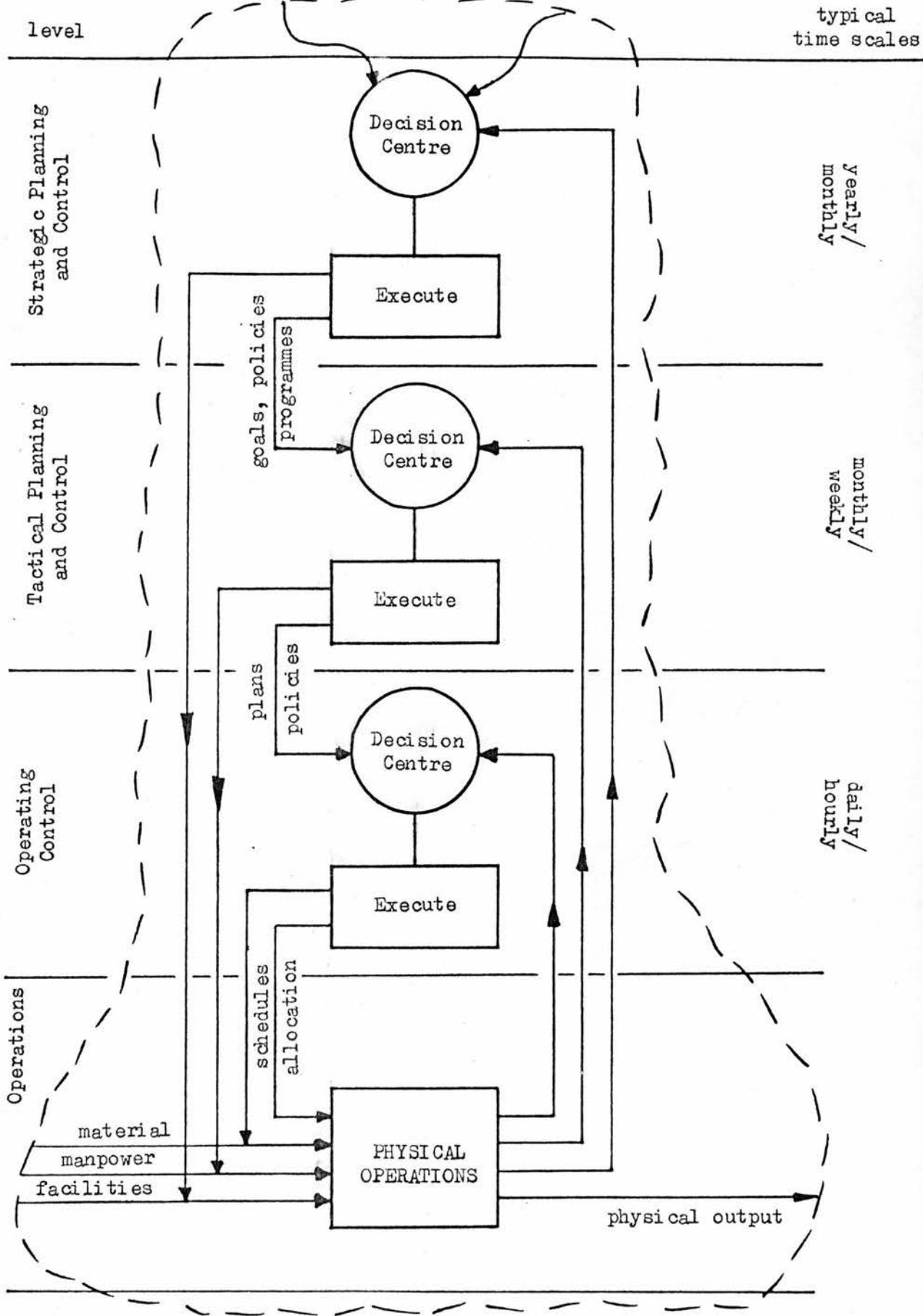


Figure 3.6: The hierarchy of enterprise control; Boyd, 1966, p.364 in Starr, 1970.

planning is concerned with the means of achieving the goals set at the strategic level and works on a monthly time scale. Operating control is concerned with the direct control of the physical operations on a daily basis. Boyd claims that this type of model has several advantages:

1. No distinction is made between manual and automated information flows, or between human and machine decisions;
2. It is applicable to all levels of the management hierarchy and to all staff activities;
3. It presents a realistic view of management objectives;
4. It is the type of model that users - i.e. managers - can understand and appreciate.

The concept of control of control is also discussed by Eilon who defines it as:

".... a mechanism that measures, monitors and responds to information about the performance of a controller. In other words, it evaluates the actions and behaviour of a control procedure and acts in order to improve it."
(Eilon, 1966.)

Bridgeman and Green (1966) similarly describe how "nested control loops" within an enterprise reflect the exercise of control over different time spans. Overall control (Boyd's strategic control) would normally be exercised by a Board of Directors whose decisions may determine the functioning of the organisation over a period of years. Within this "outer control loop" there are others operating on shorter time scales; a foreman may be responsible for performance over an eight hour shift.

The model of production control shown in Figure 3.7 is one used in production planning at Serck Audco (Ransom and Toms, 1968). Two levels of control are identified here, operational planning and

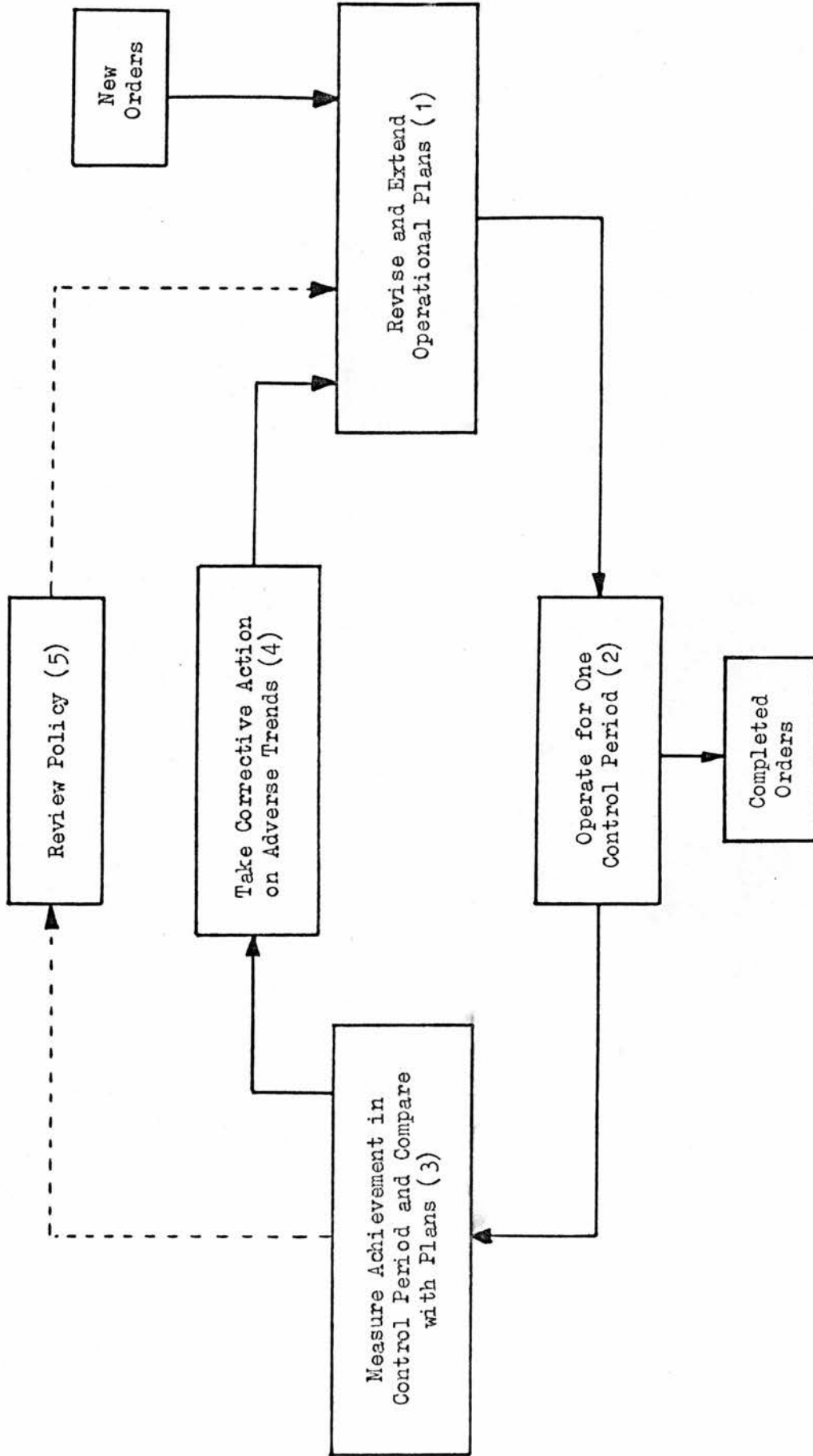


Figure 3.7: Production control cycle - Serck Audco; Ransom and Toms, 1968, p.22.

policy review. These appear to correspond to Boyd's operating and tactical levels of control respectively.

A further example may be drawn from the work of Alcalay and Buffa (1966) in developing a detailed model of a general production control system. Their aim was to derive a mathematical statement of the optimisation of a general production system and their model is shown in Figure 3.8. This model is similar to that of Boyd, depicting the management function again as a three tier hierarchy of control of control. The three tiers in the Alcalay and Buffa model are policy formulating, forecasting and planning, and day to day control.

Examples of policy formulation include decisions concerning:

- selection and design of products,
- selection and design of equipment and processes,
- system location,
- facility layout.

Examples of planning decisions include:

- system maintenance and reliability,
- cost control,
- inventory control.

There are a number of operational aspects of a production system to consider, but the control process is the same regardless of the factor being controlled. Day to day control of stocks of finished goods, for example, consists of:

- measuring the stock level,
- comparing the actual level with the norm,
- reordering a standard quantity if stocks are too low.

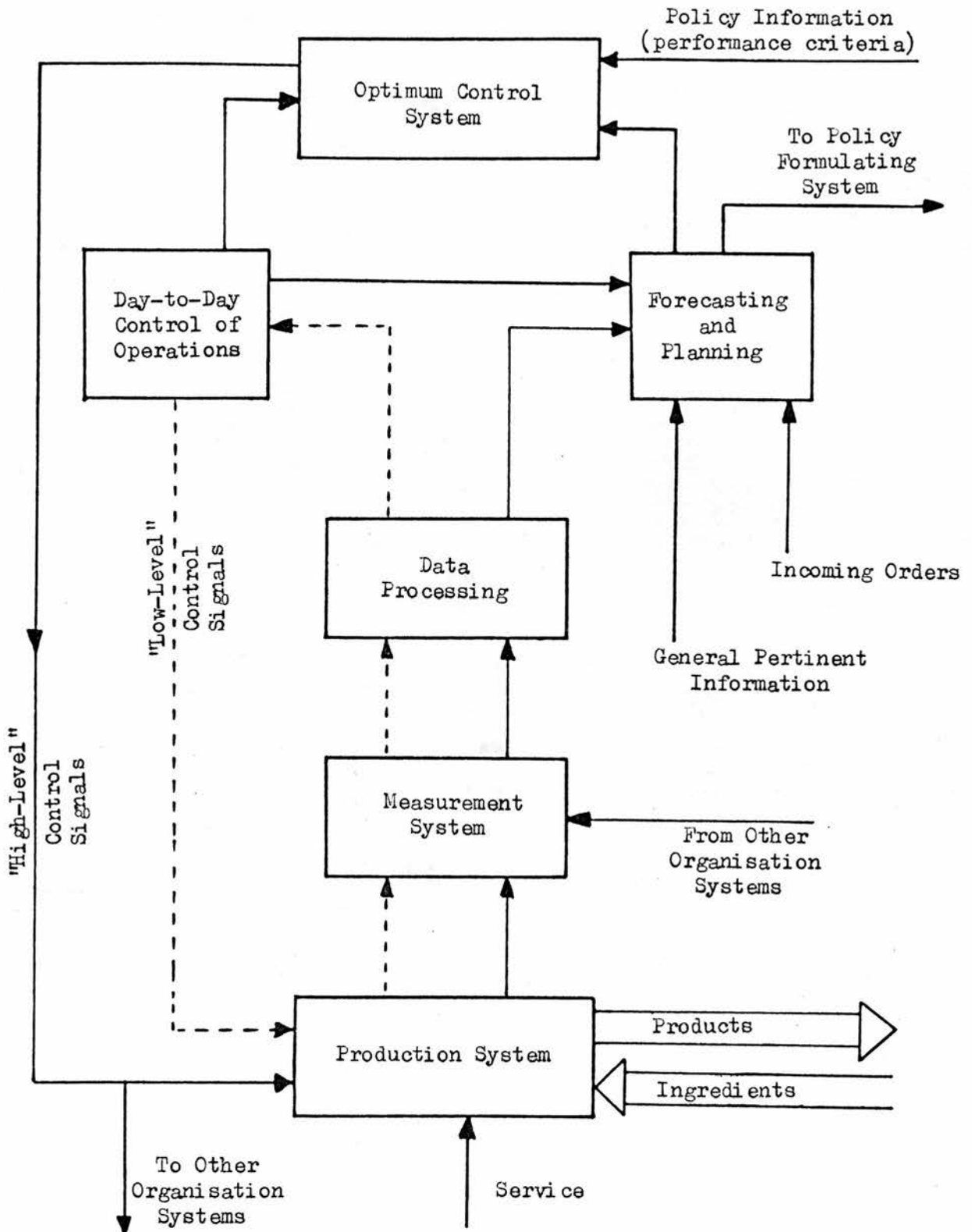


Figure 3.8: General structure of control of a production system; Alcalay and Buffa, 1966, p.308 in Starr, 1970; Buffa, 1969, p.482.

This represents a basic day to day feedback loop which adjusts stocks. In time it may become apparent that the standard reorder quantity requires adjustment, perhaps because orders are frequently not completed to schedule. This adjustment is made at the forecasting and planning level, i.e. the "optimum control system" would be altered with a new figure for standard reorder quantity in place of the previous one.

Decisions taken at the policy formulating level depend partly on information from the environment of the organisation, and partly on information passed up from the forecasting and planning level. Thus the decision to modify product design or to stop making a particular product would be made at this level.

The model of Alcalay and Buffa also shows how the control process receives inputs (a) from "other organisation systems", and (b) from outside the organisation in the form of "general pertinent information" and "incoming orders". Information from other organisation systems is seen as input to the day to day and forecasting and planning control loops. Information from outside the organisation is seen as input to the forecasting and planning and policy formulating control loops.

Together these models indicate, therefore, that the management function can be regarded as a three tier hierarchy of control of control, i.e. as a hierarchy of feedback control loops. None of the above models was formulated, even indirectly, for the purpose of job design, but as models of the management function as an information processing and control function they approach the expression of the "total task" of that function and this is one of the attributes appropriate for a theory of job design.

Production Control and Workers' Control

The work of Boyd and of Alcalay and Buffa in the field of production control resembles in certain important respects the work of Neil Chamberlain concerning workers' control. In his book, "The Union Challenge to Management Control", Chamberlain (1948) identified "three distinct phases of doing business" or three "management functions" at which the union challenge that he was describing could be directed. These three "management functions" are essentially those identified by Boyd and by Alcalay and Buffa.

Emphasis has been placed here on the invariant nature of the process of control, and it is interesting that Chamberlain should give the following quotation from Oliver Sheldon*:

"Whether capital be supplied by individuals or by the State, whether labour be by hand or by machine, whether the workers assume a wide control over industry or are subjected to the most autocratic power, the function of management remains constant." (from Chamberlain, 1948, p.20).

The three constant phases, or functions, of management that Chamberlain identifies are direction, administration and execution.

Direction concerns the definition of overall objectives, or what A.K. Rice (1958) would call establishing the primary task of the enterprise: "... the definition of objectives, the determination of what is to be done" (Chamberlain, 1948, p.22).

The ultimate criterion for such a decision depends upon whether or not a higher authority in the enterprise can set it aside. If a decision can be so set aside, then it is not direction by Chamberlain's definition. The function of direction is normally carried out by the Board of Directors.

* The Philosophy of Management, Pitman, 1924, p.48.

Administration is the function that determines how to carry out the objectives set by the direction function. Administration, therefore, is constrained by direction although it "operates within a framework of discretion" (Chamberlain, 1948, p.23) in choosing between alternative methods of satisfying overall objectives. Administration does not constitute a source of final authority and decisions made at this level may be overruled by the direction function.

Execution is the function responsible for ensuring that the decisions made at the administration level are carried out:

"If direction determines what is to be done and administration establishes how it is to be done, execution is responsible for seeing that it is done."
(Chamberlain, 1948, p.24).

Execution, in contrast to the other two levels, is distinguished by an almost complete absence of discretion.

Chamberlain also includes "a note on coordination as a management function" (Chamberlain, 1948, p.27). Coordination is carried out in conjunction with each of the three management functions described and is, therefore, not given the status of an independent management function by Chamberlain. This topic is explored in further detail below.

More recently, writing about worker participation in general - from job enrichment to worker directors - Thomason notes Chamberlain's work, claiming that the three levels of management that he identified "... are capable of providing us with all the schema that we need to organise thinking about 'participation'" (Thomason, 1973, p.138). The section that follows may thus be regarded as an exploration of this claim made by Thomason.

A Model of Organisational Information Processing and Control

It is now possible to formulate a model of organisational information processing that fulfills the three criteria stated at the beginning of this Chapter. If it is to be appropriate for job and organisational design, the model must be:

- (a) a model of the organisation as a whole;
- (b) a normative model; i.e. a model of how organisational information processing and control must be carried out if this is to be effective; and
- (c) a general model, not restricted to one type of organisation.

The model presented here is based principally upon the work of Boyd, Alcalay and Buffa, and Chamberlain that has been discussed above.

It appears both necessary and sufficient to regard the management function as a three tier hierarchy of control of control. The terminology that has been used to describe these three levels has varied from author to author. The terminology that appears to be most appropriate, and which will be used here, is given in Figure 3.9 which illustrates the basic three tier hierarchy of organisational control. The term "operating system" is taken from Miller and Rice (1967) in recognition of the fact that the model applies not only to production systems. The model as a whole is based on the simple feedback control loop and the arrowed lines represent information flows and feedbacks between each of the levels of control, between the lowest level of control (routine control) and the operating system, and between the enterprise as a whole and its environment.

"Primary decision making" is essentially what Boyd calls strategic

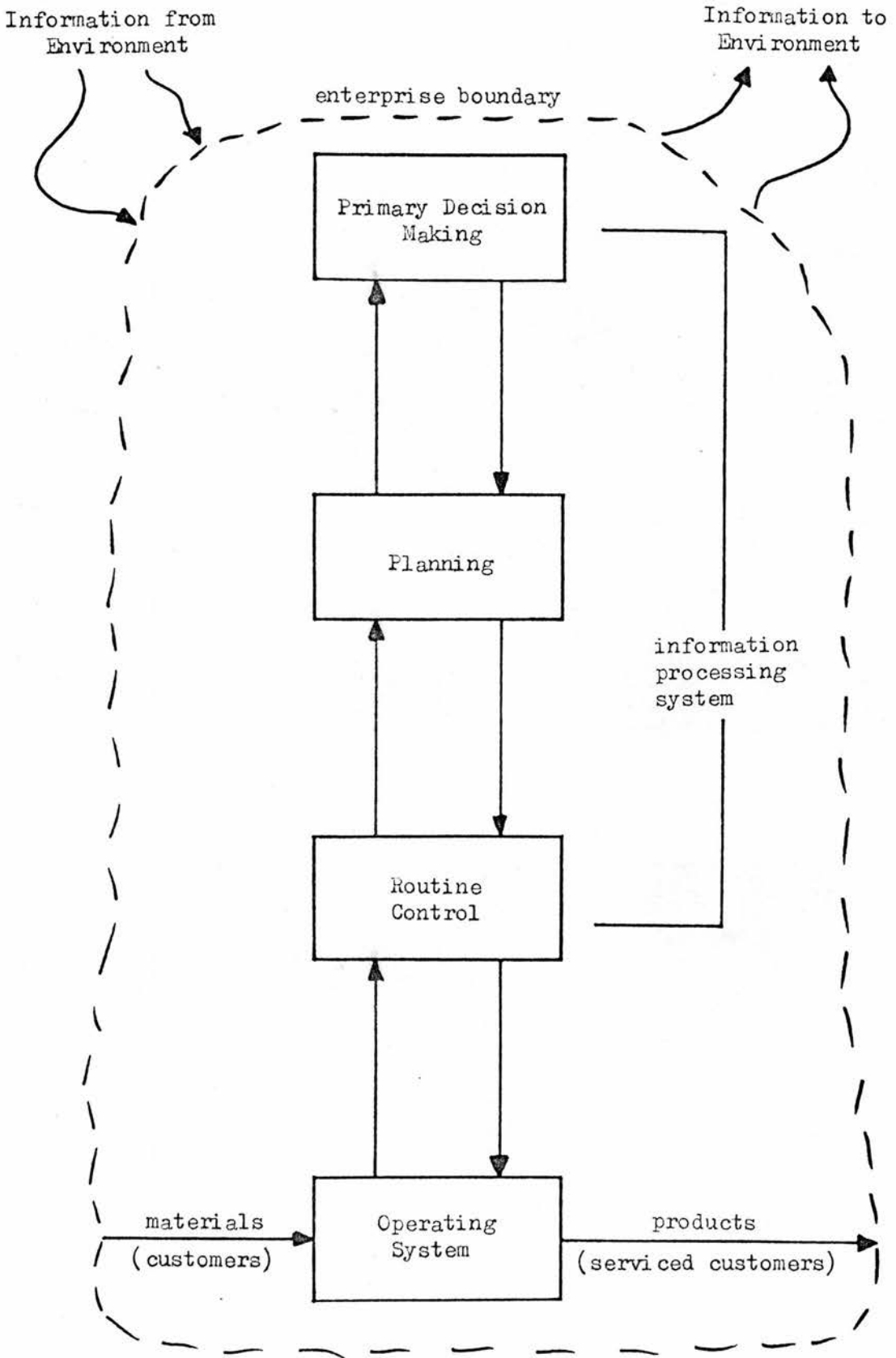


Figure 3.9: The three tier hierarchy of organisational control.

planning, what Alcalay and Buffa call policy formulation and what Chamberlain calls direction. It is assumed, a priori, that any enterprise has one overriding goal - survival. Primary decisions are defined here as decisions which determine:

1. The task or tasks of the enterprise; what products are to be made and/or what services are to be provided.
2. The financial resources to be used in achieving the task or tasks of the enterprise.

These two sets of primary decisions determine the framework within which control at the planning level takes place.

"Planning" is essentially what Boyd calls tactical planning, what Alcalay and Buffa call forecasting and planning and what Chamberlain calls administration. Planning is defined here as the determination of how the task or tasks of the enterprise are best achieved given the resources that are to be available. Control at the planning level thus determines how the operating system or operating systems of the enterprise will function, and how these operating systems will be controlled. Planning control thus establishes the performance standards which the operating systems are to work to, and which the routine control level is to monitor.

"Routine control" is essentially what Boyd calls operating control, what Alcalay and Buffa call day-to-day control, and what Chamberlain calls execution. Routine control is defined here as the day-to-day monitoring and adjustment of the operating system in accordance with the standards and procedures established at the planning level. The planning level of control may determine the expected weekly output of a machine and how this is to be measured. Routine control is thus concerned with measuring the output of the

machine and determining how to increase or reduce that output if it deviates from the standard. In any operating system there will be a number of factors that the routine control function must monitor.

In a production system, these will include:

- throughput times of orders
- product quality
- work methods
- operator efficiency
- allocation of tasks
- size of the work force
- layout of facilities
- hours of work
- maintenance of equipment
- material wastage.

Routine control is distinguished from the other two levels of control by the fact that decisions made at this level do not result in change. Only primary and planning decisions can alter the routine control function or the operating system. Routine control works within the framework established at the planning level.

The three tier hierarchy of control of control illustrated in Figure 3.9 has the following three configurational properties:

1. Each level is a "controller" in its own right. It operates by measuring the performance of the level below, comparing actual with desired performance, deciding what action should be taken, and passing on instructions to ensure that this action is taken.
2. Each level constrains the area of freedom of the level below. Primary decisions constrain the area within which planning

is carried out; planning decisions constrain the routine control function.

3. Each level operates continuously, if on different time scales. Primary decisions may have only been taken once, but they must be under continuous review, and must be altered as information from the planning level and from the environment of the enterprise may indicate. Planning decisions and routine control decisions must be reviewed constantly in a similar manner. Primary decisions may constrain the activities of the enterprise over a number of years, planning decisions may also constrain activities over a period of years, and routine control is likely to be concerned with daily, weekly or monthly performance.

It is possible to regard the relationship between the enterprise and the environment as such that the output of one is the input of the other. This relationship is illustrated in Figure 3.10. The primary decision to obtain more financial resources will take the price of money into account; the planning decision to re-equip a department with automatic machines may depend partly on the availability and price of the machinery and partly on the availability and price of labour; the routine control decision to replenish stocks of material will take into account the reliability of each of the possible vendors. Information about the environment of the enterprise may be regarded as input to each of the three levels of control.

In an enterprise that has more than one operating system, the problem of coordination arises. The large enterprise may have a number of operating systems, such as:

- production departments,

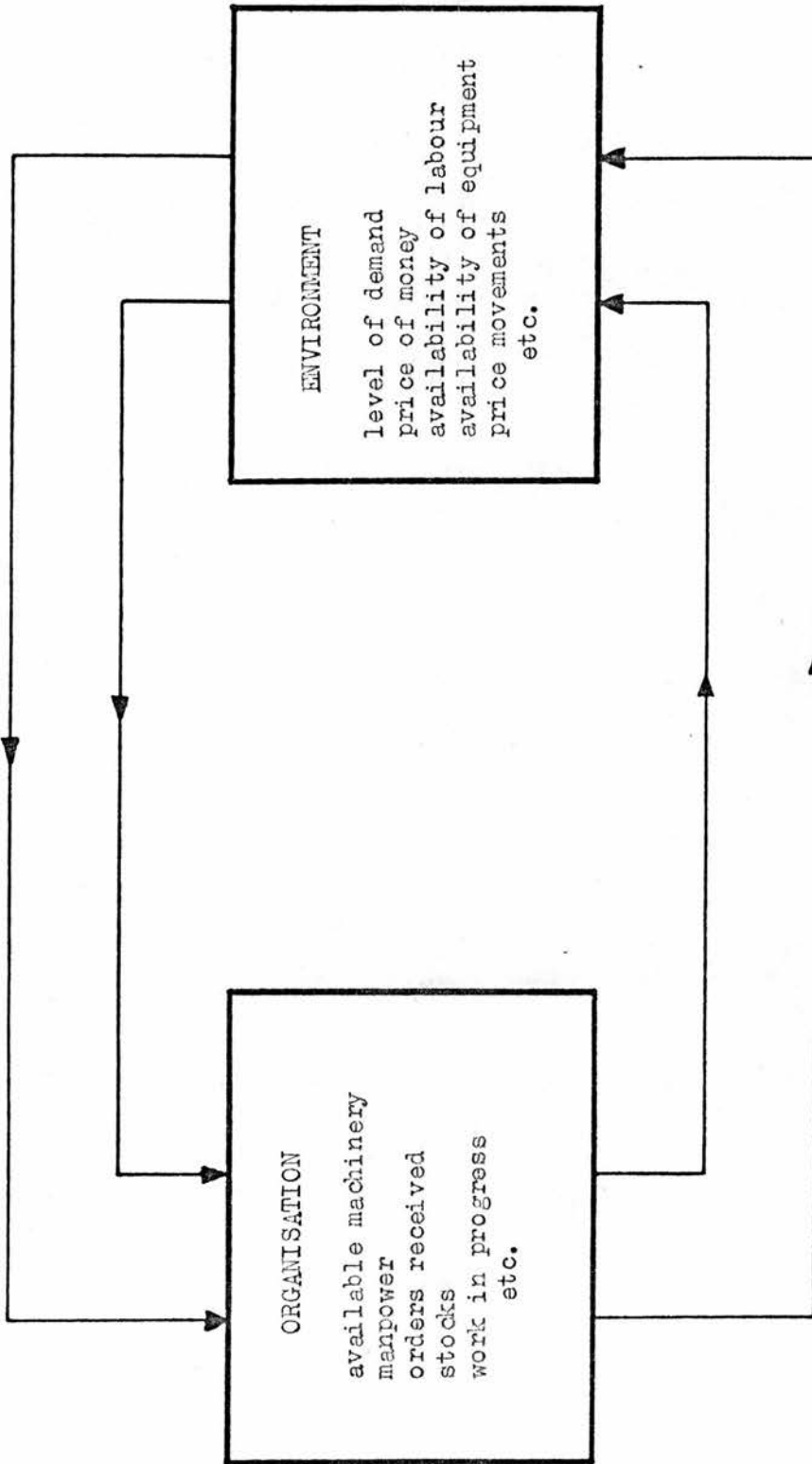


Figure 3.10: Relationship between the organisation and its environment.

- materials purchasing,
- marketing and distribution,
- personnel,
- accounting,
- research, development and design.

The hierarchy of organisational control shown in Figure 3.9 will apply to each operating system, but coordination between the respective control hierarchies is necessary. Coordination may be regarded as an exchange of information between the control hierarchies of different operating systems. This is illustrated in Figure 3.11. In particular, coordination may be regarded as the process of transmitting information concerning the action decisions of one controller to another controller or controllers. This is illustrated in detail in Figure 3.12 which also indicates that this information exchange is mutual. Where there are three or more operating systems with three or more control hierarchies, each level of control in each control hierarchy will transmit information to and receive information from all other controllers at that level concerning their respective action decisions.

As a whole, this model states that if information processing and control in an organisation is to be effective, an identifiable set of control and coordination tasks must be carried out. These tasks taken together constitute the management function. The complete model of organisational information processing and control is shown in Figure 3.13; only two operating systems and their respective control hierarchies are illustrated in Figure 3.13, but the model is easily extended to take account of any number of operating systems. This model, therefore, provides a framework for analysing the

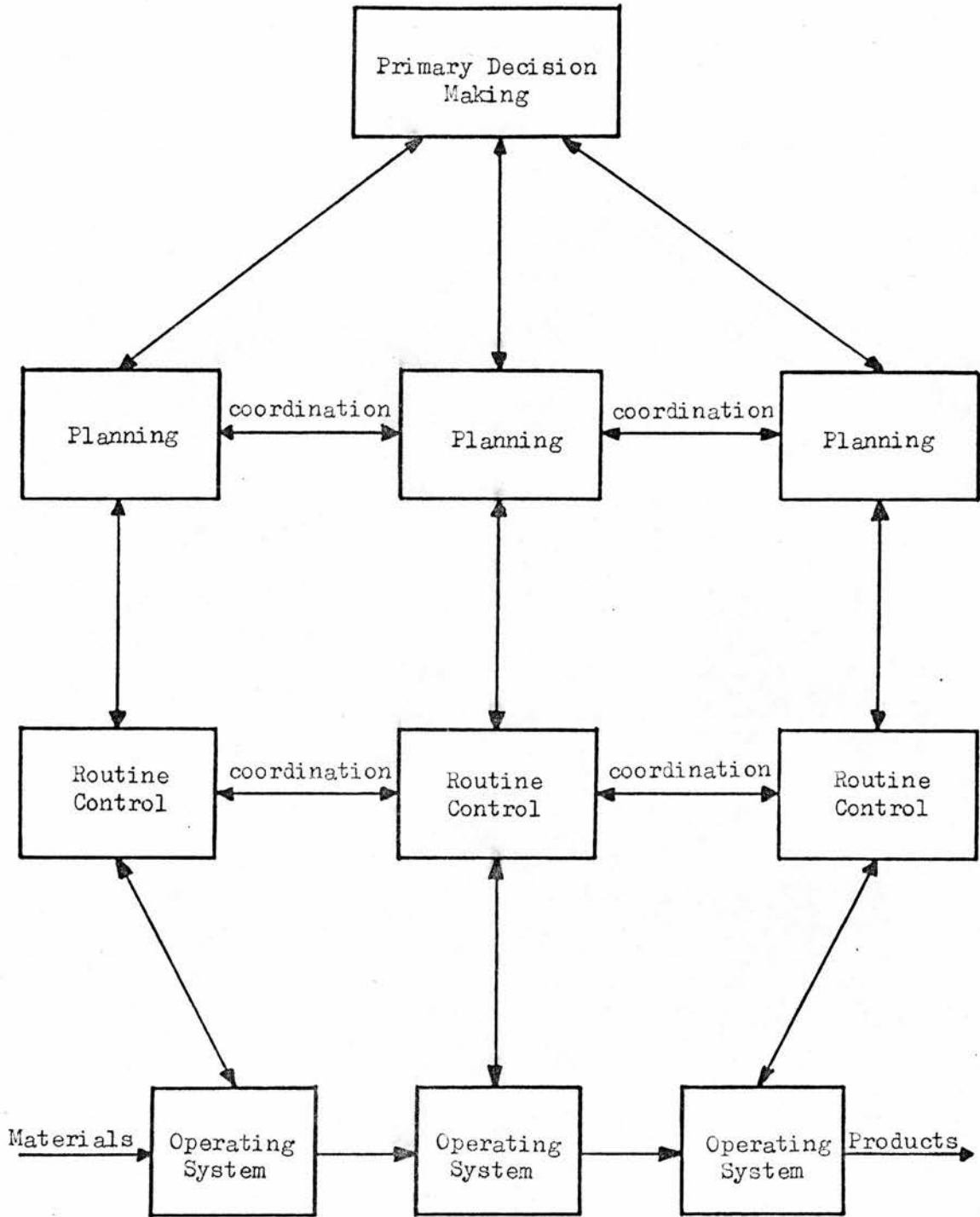


Figure 3.11: Coordination in the hierarchy of organisational control.

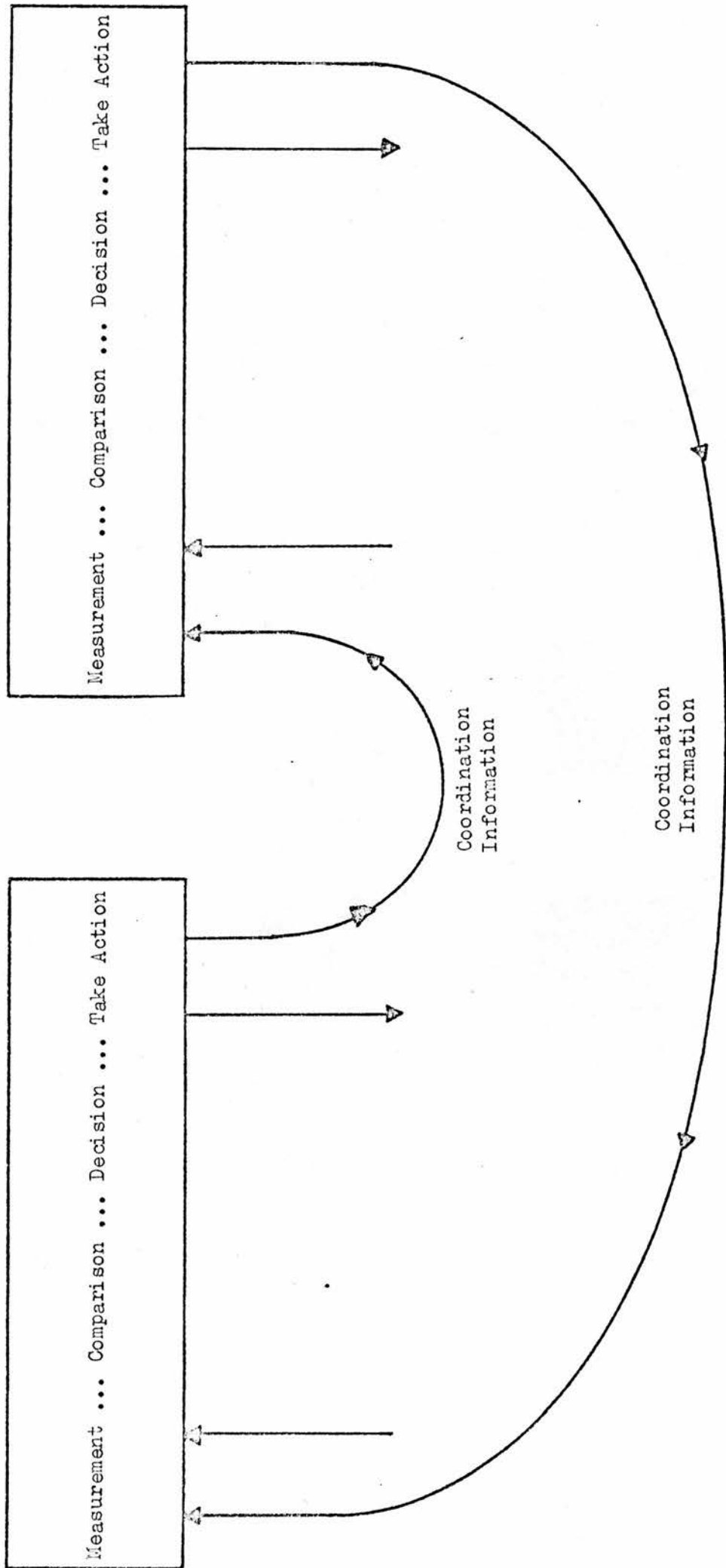


Figure 3.12: Coordination between the control functions of two operating systems.

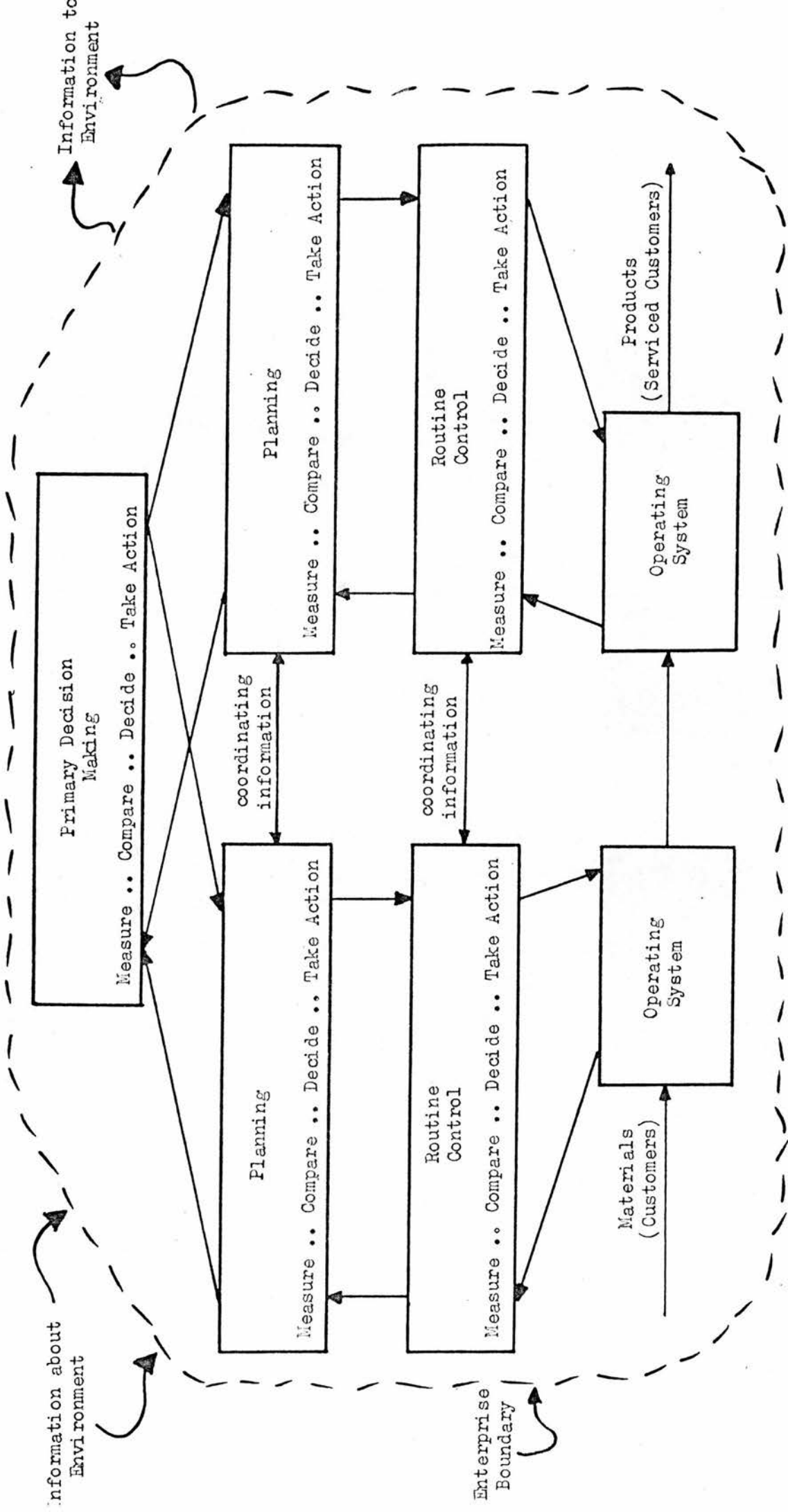


Figure 3.13: A general model of organisational control.

"total task" of an enterprise, the tasks of the operating system and the tasks of the information processing system. This is a model of the organisation as a whole. The model gives no indication as to who or what should carry out either the tasks of the operating system or the tasks of the information processing system. This model can be used, therefore, to analyse any type of organisation of any size and is, therefore, a general model.

This model possesses the three characteristics considered to be appropriate for the purposes of job and organisational design. Nothing has been said up to this point about how tasks should be allocated to members of an organisation because this model on its own gives no indication as to how this should be done. The following Chapter attempts to show how job characteristics that have come to be regarded as desirable can be made operational using this model.

CHAPTER 4:

TOWARDS A GENERAL THEORY OF JOB AND
ORGANISATIONAL DESIGN.

The Aim of this Chapter

At the end of Chapter 2 above, a number of conclusions concerning the current status of job design theories were presented. It was argued that while there appears to be wide agreement over the objectives of job design, none of the current theories adequately solves the problem of making these objectives operational, that is of translating prescription into action. In Chapter 3 above, an attempt was made to develop a general model of organisational information processing and control, and it was argued that this model provides an appropriate framework for operationalising job design objectives. This type of model was considered to be appropriate for two principal reasons:

1. The function of management can be conceptualised as an information processing and control function, and
2. Since job design takes place at the interface between managerial and non-managerial tasks, a method of analysing managerial tasks is a necessary basis for implementing job design.

It is the aim of this Chapter to develop a general theory of job and organisational design based on the information processing and control model described above. But it is necessary first to examine in detail how specific job design objectives, i.e. desirable job characteristics, can be made operational. Some of these objectives are more easily made operational than others. It is probably easier to give a job more "variety" than it is to increase

its "task identity". The model of organisational information processing and control described above, however, has properties in common with psychological theories of skill performance and learning that are also based on cybernetic concepts. So it is to the desirable job characteristics "feedback" and "continuous learning" that attention is first directed here.

Feedback and the Performance of Skill

Models of man as an information processor are now commonplace in psychology, certainly amongst "cognitive" as opposed to "stimulus-response" psychologists (see the brief discussion on p.119 above). If one piece of work is to be singled out as having contributed most to this development, it is undoubtedly that of Miller, Galanter and Pribram (1960). Their work is outlined below. One area in which the concept of man as an information processor is of fundamental importance concerns theories of skilled performance.

To the psychologist the word "skill" means a great deal more than everyday use of the word implies. Universal human abilities such as walking, breathing, talking, scratching and so on are regarded as skills by the psychologist, and these skills can be shown to have characteristics in common with what are popularly regarded as skills, such as playing tennis or rock climbing.

Skilled performance appears to possess three major characteristics:

1. it involves an organised sequence of activities;
2. it is purposive; and
3. it is dependent upon feedback.

(Fitts and Posner, 1967, pp.1-2.)

The nature of the feedback that the performer requires varies with the skill being exhibited, but:

".... almost every act is dependent upon comparison either of feedback with input, so that he may determine the appropriateness of his previous responses, or a comparison of progress toward a goal with some conception of what is desired." (Fitts and Posner, 1967, p.3.)

Feedback dependency thus extends to the performance of universal skills as well as to special learned skills. It is difficult and frequently impossible to carry out the simplest perceptual-motor tasks without adequate feedback. Stratton's experiments in the late 1890s with spectacles that inverted the retinal image of the wearer illustrated the necessity for adequate visual feedback (see Annett, 1969, p.19). A great deal of practice is required before the wearer can overcome this disruption to normal visual feedback, and move around a room without bumping into furniture. The difference between the wearer of these spectacles and a blind person is that the former is still receiving visual feedback of a sort. Similarly, delayed auditory feedback makes speech inordinately difficult. This can be demonstrated using a tape recorder with a second playback head displaced from the record head so that the speaker hears his recorded voice through headphones a second after he has spoken. This arrangement quickly induces slurring of speech, a reduction in speed, increase in pitch and intensity and stuttering (see Annett, 1969, pp.19-20). Performance of the simplest universal skills as well as of the most complex learned skills, is dependent, therefore, upon adequate feedback.

Feedback and the Learning of Skill

Not only is performance dependent upon feedback, the learning of a skill is generally difficult or impossible in its absence. Thorndike's "law of exercise" in its original formulation stated that the probability of an act being performed correctly increased with practice or exercise (see Hilgard and Bower, 1975, p.33). A number of repetitive skills such as rote memorising and muscular skills may be explained in this way. Thorndike, however, eventually altered his view of the law of exercise. The type of experiment used to disprove the original formulation of the law were those in which repetition took place without feedback. Thus, asking someone to draw lines three inches long on paper while blindfold does not lead to any improvement in performance over any length of time, however protracted. When the person is informed after each attempt whether the line that he has just drawn is too long or too short, performance does begin to improve. The law of exercise is thus restated rather than repealed; repetition of "connections" - that is repetition with feedback - improves performance, but repetition of "situations" does not (see Hilgard and Bower, 1975, p.39).

The acquisition of skill thus requires information processing of some kind on the part of the learner. This information processing is concerned with the objectives of the learner and the consequences of actions made in the pursuit of those objectives. Feedback can thus be seen as contributing more to the process of learning than the correction of preceding actions. Fitts and Posner (1967, p.28) argue that feedback serves three functions in providing:

- (a) knowledge of results,
- (b) reinforcement, and

(c) motivation.

If a skill is to be learned, knowledge of the results of each attempt must be available. But feedback also provides reinforcement in that responses, or attempts to perform, that are seen to be successful are more likely to occur again than responses that have failed. Fitts and Posner argue further that:

"Much of the incentive which motivates the activities of man comes from the consequences of his own movement. If behaviour is goal directed, then the successful approach to the goal can serve to sustain behaviour."
(Fitts and Posner, 1967, p.27)

Feedback thus provides more than knowledge of results and reinforcement of successful attempts, it has a motivational component as well.

Examining the development of motor skills in children, Connolly (1974) presents the "model of skill" shown here in Figure 4.1. Connolly's illustrations of this model concentrate on motor skills but he emphasises that the process "... has obvious similarities to other cognitive activities, to problem solving, concept formation and aspects of perception" (Connolly, 1974, p.540). The problem of skill learning and performance, he argues, is the problem of translating a plan of intention into a programme of action. Thus for motor skills:

"The plan is expressed via the effector organs in movements and postures the success and adequacy of which must be evaluated in relation to the plan. This brings in the notion of feedback." (Connolly, 1974, p.538)

There are two types of feedback in Connolly's model:

1. through the musculature and other senses (intrinsic feedback),
and
2. through knowledge of the consequences of the actions (extrinsic

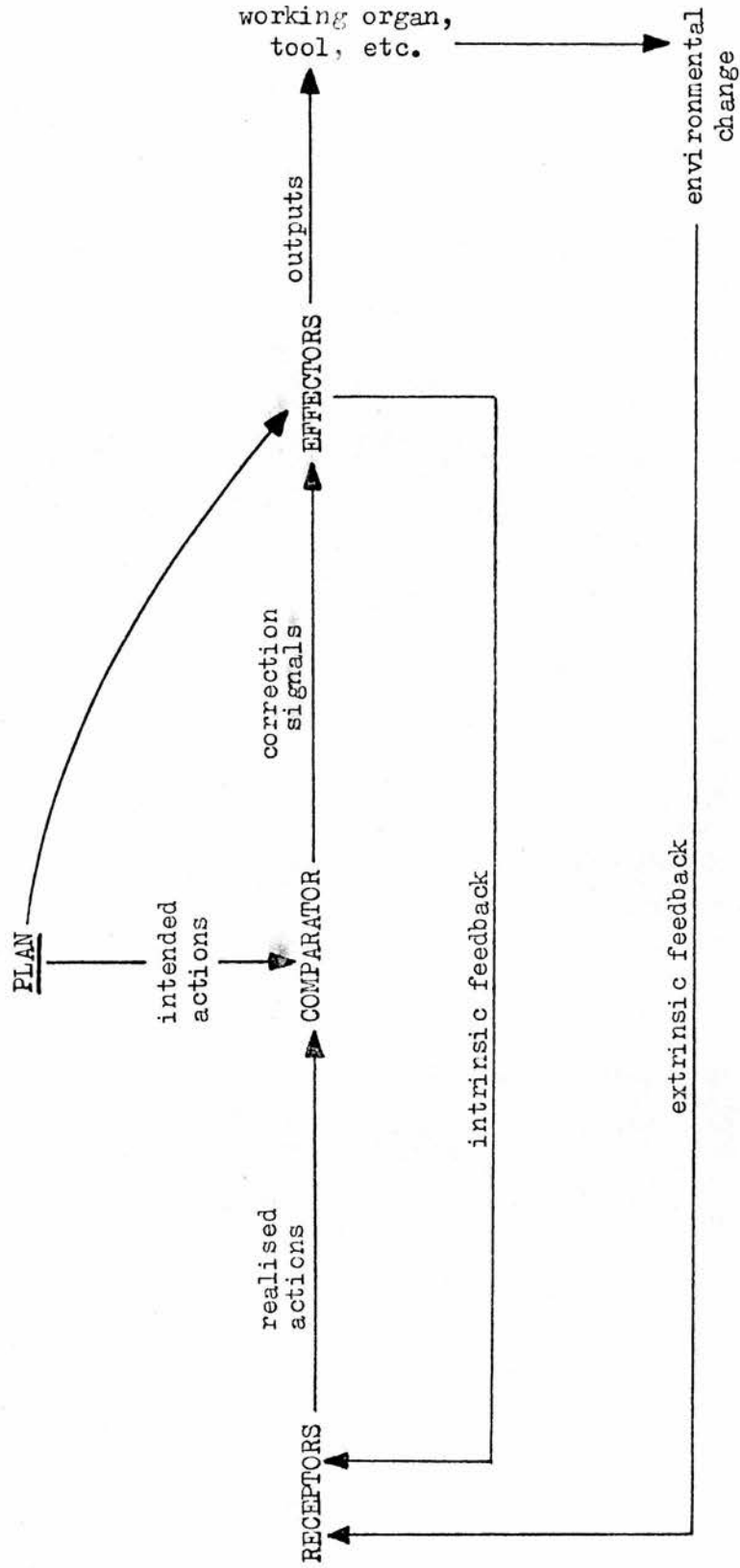


Figure 4.1: The basic logical components of a system with feedback control - used to explain motor behaviour; from Connolly, 1974, p.539.

feedback).

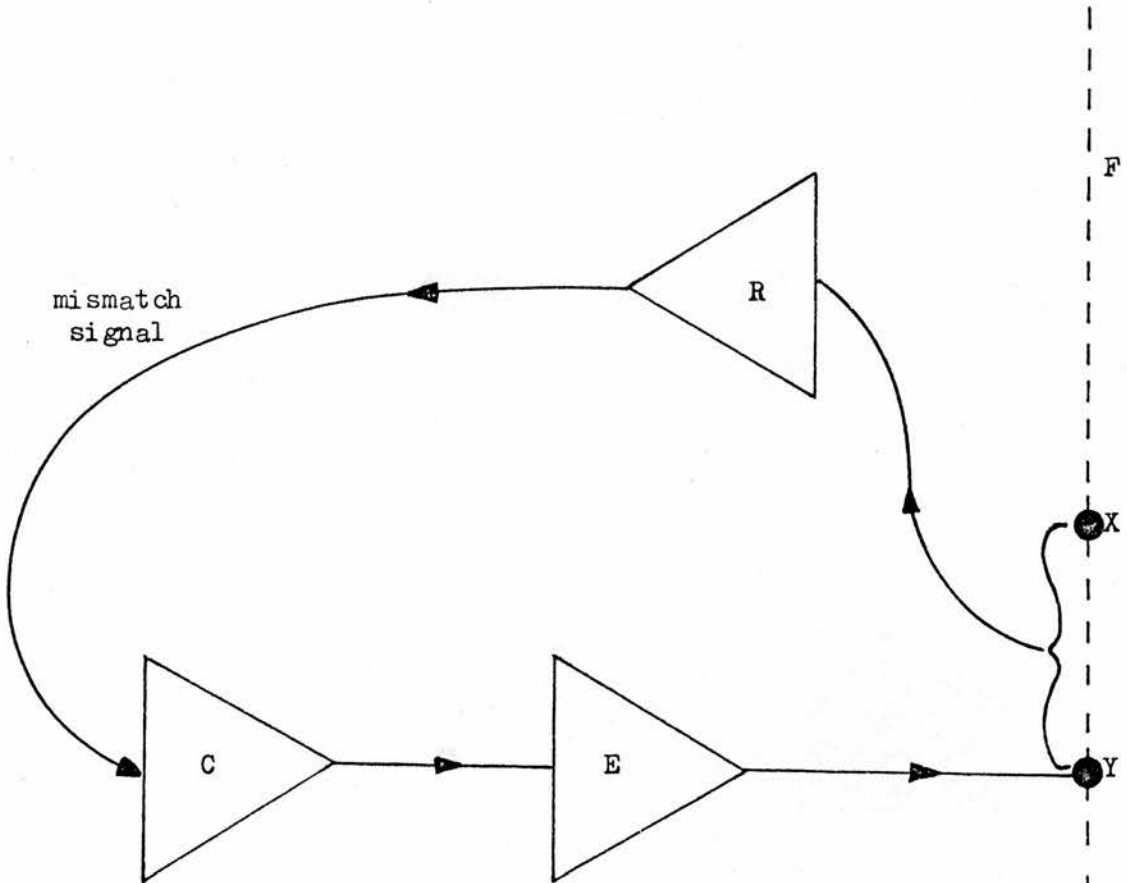
The plan "instructs" the effector organs - muscles - which produce the behaviour required, in this case a particular motor skill.

The results of this behaviour upon the environment are picked up by the receptor mechanisms (extrinsic feedback) and this along with information about the state of the effectors themselves (intrinsic feedback) is sent to the comparator. The comparator, also working under instructions from the plan, decides upon the appropriate corrective action to take for the next attempt. This model of skill is, therefore, based on the simple feedback control mechanism illustrated in Chapter 3, in Figure 3.2.

Feedback and Behaviour

These attempts to explain the processes of skill performance and learning in terms of information processing reflect models of human behaviour as a whole that are based on the same concepts. Any human behaviour that is purposive can be interpreted in the same terms used to describe skill performance and learning. For example, Mackay's (1956) "information flow model of human behaviour" is shown in Figure 4.2. This model contains, Mackay argues, the minimum requirements of an information flow system that is to exhibit purposive behaviour. There are clear similarities between this model of human goal-guided behaviour and Connolly's model of skill described above; these models are again both based on the simple feedback control mechanism (Figure 3.2).

The classic attempt to base a theory of human behaviour on cybernetic concepts is that of Miller, Galanter and Pribram (1960) whose book "Plans and the Structure of Behaviour" has become



- F - the line upon which X and Y are assumed to lie.
 X - the desired (ie goal-guided) activity.
 Y - the present activity.
 R - the receptor system.
 C - the control system.
 E - the effector system, the "active agent".

Figure 4.2: The minimum requirements for goal-guided activity;
from Mackay, 1956, p.360.

".... a classic in the current Zeitgeist of cognitive psychology..." (Hilgard and Bower, 1975, p.148). As a cognitive theory it endows man with some kind of "internal representation" or "schema" of himself and of his environment. This schema, it is postulated, is used in a purposive way to determine behaviour. The name that Miller, Galanter and Pribram give to this internal representation of the world is "Image":

"The Image is all the accumulated, organised knowledge that the organism has about itself and its world." (Miller, Galanter and Pribram, 1960, p.17)

The problem to which Miller et al direct their attention concerns how this Image becomes translated into behaviour. They suggest that a "Plan" is necessary, a set of instructions analagous to a computer programme that guides and controls the required behaviour. (Connolly's (1974) model of skill outlined above is based on the work of Miller, Galanter and Pribram.)

Human behaviour is normally capable of being described on a number of different levels. The behaviour of a high-jumper for example may be described:

- in terms of the biochemical changes taking place in his blood and muscle tissues;
- in terms of physiological responses such as heartbeat, blood flow and oxygen demand;
- in terms of his gross motor actions, concerned with running and jumping;
- in terms of winning a medal for the highest jump of the contest.

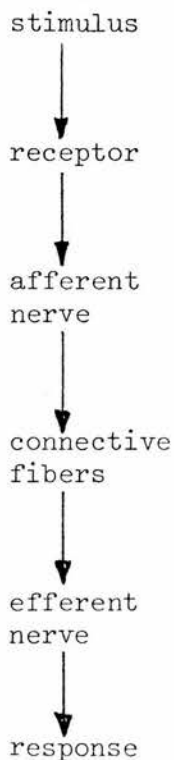
An adequate account of behaviour, argue Miller et al, should, therefore, describe all levels simultaneously:

"The point is that we do not want to pick one level and argue that it is somehow better than the others; the complete description must include all levels. Otherwise, the configurational properties of the behavior will be lost." (Miller, Galanter and Pribram, 1960, p.13)

The organisation of human behaviour, they argue, is hierarchical and may be illustrated by an analogy with a computer programme in which instructional routines and sub-routines can be hierarchically "nested". Their definition of "Plan", therefore, is as follows:

"... any hierarchical process in the organism that can control the order in which a sequence of operations is to be performed." (Miller, Galanter and Pribram, 1960, p.16)

Miller, Galanter and Pribram argue further that accounts of behaviour must be based on recognisable, elementary units of behaviour, "... something that a psychologist can use as a biologist uses cells, or a physicist uses atoms ..." (Miller, Galanter and Pribram, 1960, p.21). The classic fundamental unit of analysis in psychology is the reflex arc, outlined in Figure 4.3. The reflex arc



is dependent on antecedent stimuli to set it in motion; it describes behaviour in purely reactive terms. Neural tissue, however, is active rather than simply reactive, and is not dependent upon outside excitation to put it into action. As an explanation of purposive human behaviour, the reflex arc is inadequate. Behaviour, argue Miller, Galanter and Pribram, is determined not just by stimuli but by comparisons between what is actually happening and what should be happening. They call this comparison a "Test":

Figure 4.3: Components of the reflex arc

".... the response of the effector depends upon the outcome of the test and is most conveniently conceived as an effort to modify the outcome of the test."
 (Miller, Galanter and Pribram, 1960, p.25)

Behaviour is thus started and maintained by an incongruity between the existing state and the state that is to be achieved.

Behaviour will then last until the incongruity is removed. Miller, Galanter and Pribram illustrate these concepts by what they call the "TOTE Unit", and this is shown here in Figure 4.4; TOTE is an acronym for Test, Operate, Test, Exit. The TOTE unit is essentially another version of the feedback control mechanism shown above in Figure 3.2. And Miller, Galanter and Pribram state that:

"The interpretation toward which the argument moves is one that has been called the 'cybernetic hypothesis' namely, that the fundamental building block of the nervous system is the feedback loop." (Miller, Galanter and Pribram, 1960, p.26)

Using the TOTE unit, or the feedback loop, as the basic "building block", Miller, Galanter and Pribram suggest that complex behaviours can be explained by "nesting" TOTE units within each other.

Behaviour can then be described as a series of attempts to carry out plans which comprise a number of sub-plans which themselves each comprise a number of sub-sub-plans, and so on.

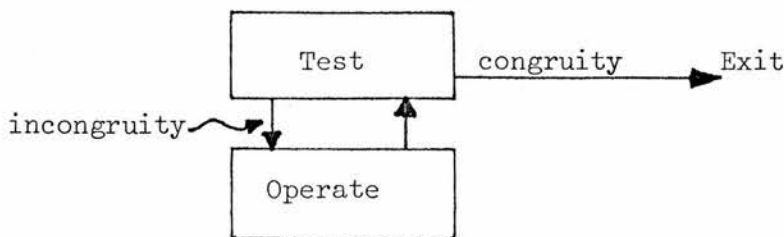


Figure 4.4: The TOTE Unit; from Miller, Galanter and Pribram, 1960, p.26.

Consider a man hammering a nail into a piece of wood. He tests the nail after each blow to see if the head is flush with the

surface of the wood, and until it is, he will continue to hammer (i.e. to operate). This action may be part of another plan that concerns joining two pieces of wood together; this plan may in turn be nested inside the plan of making a chair; this plan may in turn be nested inside the plan of earning a living, and so on.

Feedback, Learning and Development

The motivational role of feedback has been discussed above. A number of writers on human motivation have argued that the opportunity to develop skills and knowledge, that is the opportunity to learn, is motivating in itself. Herzberg's (1966) theory of psychological growth, for example, claims that humans have innate needs for:

- knowing more,
- acquiring relationships in knowledge,
- creativity, and
- real growth (improved perception of reality).

White (1959) has suggested that "effectance motivation" should be regarded as innate, referring to a basic need to develop "competence":

".... activities in the ultimate service of competence must be considered to be motivated in their own right. It is proposed to designate this motivation by the term effectance and to characterise the experience produced as a feeling of efficacy." (White, 1959, p.329)

Maslow (1943) also discusses the motivational role of curiosity, learning and experimenting and argues for the existence of:

".... a desire to understand, to systematise, to organise, to analyse, to look for relations and meanings."
(Maslow, 1943, p.385)

Gardner Murphy (1958) argues that the nature of man is determined by three factors. First, man is a product of the process of evolution which has given him the characteristics that distinguish him from all other forms of life. Second, this biological framework is subjected to a "cultural molding" as the knowledge and beliefs of individuals become transmitted to others. In addition to these influences on man's behaviour, however, "There are deep forces within us that strive fundamentally for gratification of the need to understand" (Murphy, 1958, p.18). Murphy refers to this need as a "third human nature". Arguing more as a social philosopher than as a psychologist, Murphy claims that:

"This urge towards discovery, this living curiosity, beginning with a sort of 'freeing of intelligence' from cultural clamps and moving forward in a positive way activated by thirst for contact with the world and for understanding and making sense of it, will begin to develop a society in which the will to understand is the dominant new component." (Murphy, 1958, p.19)

The motivational role of feedback or knowledge of results in any human activity may, therefore, ultimately be attributed to an innate desire to expand human capabilities, to learn and to understand more, to develop more effective means of living and of coping with our environment. It is clear that this view has a philosophical as well as an empirical component.

Isomorphic Models : Organisational Control and Learning

It was the intention of Stafford Beer, whose work is outlined in the previous Chapter, to explore the managerial implications of the similarities between his model of the human nervous system and his conception of organisational management. It is the

intention here, on the other hand, to explore the implications for job design theory of the similarities between the model of organisational control developed in Chapter 3 above and the models of human learning described in this Chapter.

Postulating the foundations of general system theory, Ludwig von Bertalanffy (1968) makes the claim that:

"... there exist models, principles, and laws that apply to generalised systems or their subclasses, irrespective of their particular kind, the nature of their component elements, and the relations or 'forces' between them."(von Bertalanffy, 1968, p.31)

Such models, principles and laws are called "isomorphisms" (von Bertalanffy, 1968, p.32). The models describing organisational control and the models describing the human learning process that have been discussed above clearly display a number of structural similarities since they are all derived from the same basic concept - the feedback control loop. These models, therefore, are isomorphic. Von Bertalanffy claims that there are at least three reasons for the existence of isomorphisms:

1. They arise partly from our perceptions of the world around us, from the ways in which we choose to look at it.
2. They arise also partly from the structure of reality itself and our ability to impose our conceptual constructs on that reality, to make schematic, abstract pictures of it.
3. They arise also from the assertion that all "systems" have common properties, that there are universal principles that apply to systems in general.

These statements represent the foundation of general system theory and reflect the fundamental cybernetic hypothesis regarding the universal nature of the process of control. Control of operations in an organisation can be conceptualised and analysed in precisely the same terms as "control" of human goal-directed behaviour. It is suggested here, therefore, that the isomorphic nature of these two types of model creates an appropriate basis for a general theory of job and organisational design.

Basis for a General Theory of Job and Organisational Design

At the end of Chapter 2 above, it was suggested that a theory of job design should incorporate four components. These components are:

1. A theory of human motivation and/or human nature.
2. A model representing the situation that is to be designed or changed; it was further suggested that this should be an organisational model.
3. A statement of job design objectives, in terms of desirable job characteristics, derived from component 1 - the theory of human motivation.
4. A technique for implementing the desired changes, based on component 2 - the organisational model.

The objective of this section, therefore, is to postulate a general theory of job and organisational design incorporating these four components. Each of the four components will be examined in turn.

Component 1, a theory of human motivation and/or human nature:

One of the conclusions reached at the end of Chapter 2 above

was that theories of human motivation that have been incorporated in job design theories have been influenced greatly by the work of Maslow. It is not the intention here to contest that influence but largely to accept it, and to base this first component upon the assumption that Maslow's theory (with some slight modification) is essentially correct. In the light of recent research concerning the hierarchical ordering of human needs that Maslow specifies, Lawler's (1973) reconsidered list of needs appears to be fairly representative of current thought. He identifies six basic needs:

- (a) existence needs - sex, food, water, oxygen.
- (b) security need.
- (c) social need.
- (d) need for esteem and reputation.
- (e) autonomy or freedom need.
- (f) need for competence and self-actualisation.

(Lawler, 1973, p.32)

Lawler points out that research evidence has not supported Maslow's contention that these needs are arranged in a five- or six-step hierarchy of prepotency. Lawler claims that it is safer to assume only a two-step hierarchy; when existence and security needs are fulfilled, the remaining needs become potent in an essentially unpredictable way. The need for competence and self-actualisation, in Lawler's scheme, retains the characteristic of being the only need that does not disappear on fulfilment. The other needs, once met, cease to be motivating agents; the experience of self-actualisation, on the other hand, stimulates the desire for more.

The "highest order need", therefore, is that which concerns competence and self-actualisation. It has been suggested above that

the fulfilment of these needs is based on opportunities for learning which are in turn dependent upon adequate feedback. The provision of continuous learning and feedback of performance results have been recognised as desirable job characteristics by a number of job design theorists. These characteristics will, therefore, be emphasised in Component 3, described below.

Component 2, a model representing the situation that is to be designed or changed:

The model of organisational information processing and control that was developed in Chapter 3 above constitutes this component.

Component 3, a statement of job design objectives, in terms of desirable job characteristics:

The general agreement amongst job design theorists concerning the types of job design characteristics regarded as desirable was noted at the end of Chapter 2, above. In so far as these characteristics are based upon similar theories of human motivation, this agreement is not remarkable. Since Component 1 of the theory put forward here is based on a similar theory of motivation, it is not the intention to argue with the list of desirable job characteristics given in Figure 2.10 above. It is suggested, however, that emphasis should be placed on the characteristics "provision of continuous learning" and "feedback" for three reasons:

1. these characteristics are related to the highest order need for competence and self-actualisation;

2. the model of organisational information processing and control and the models of the learning process that were described above indicate various ways in which these particular characteristics can be made operational;
3. making these characteristics operational can lead automatically to the incorporation of other desirable characteristics in the jobs concerned.

The provision of feedback facilitates learning and improvement in job or task performance. But once a job or task has been learned, the continued provision of feedback will serve to maintain the level of performance achieved but will lead to no further learning. This is particularly true of non-managerial jobs. There is only so much that one can learn about screwing wheels onto cars, assembling electronic components, or taking thermoformed sheets of plastic from a machine. The provision of continuous learning thus requires more than the provision of continuous feedback. Once one has learned how to carry out a set of instructions, or "plan" (Miller, Galanter and Pribram, 1960; Connolly, 1974), effectively learning will cease. Learning can only continue if the person can alter the plan itself, and where that plan is in fact a sub-plan nested within a larger plan or series of plans. Continuous learning can only take place where the original plan can be changed in the direction of performing some higher order plan more effectively, and not just in the direction of performing the original plan more effectively.

The provision of continuous learning in work thus requires that the job itself can be changed by the person who is performing it; feedback of results can be used not only to improve individual

task performance but also to improve the performance of the operating system itself. The original plan - carrying out a production task - lies within a higher order plan - controlling the operating system. Continuous learning can only be provided, therefore, where there is opportunity to alter a lower order plan in order to improve overall performance of a higher order plan.

The total task of any organisation can be regarded as a hierarchy of such plans, sub-plans, sub-sub-plans and so on. The overriding plan concerns survival of the organisation. From this arise plans concerning the most effective use of the resources available. The lowest order of plan that has to be carried out concerns the various production, service and clerical tasks on the shop floor and in the office. The provision of continuous learning in work, therefore, depends upon the allocation or reallocation of the various sub-plans of the organisation to its members. This issue will be considered in more detail below.

Giving operators more control over the work that they perform in order to provide continuous learning entails the transfer of managerial tasks to those who previously performed exclusively non-managerial tasks. So providing continuous learning can automatically provide other desirable job characteristics such as responsibility, autonomy, and variety. This issue will also be considered in more detail below.

Component 4, a technique for implementing the desired changes:

The technique advocated here is a ten-step method of organisational analysis that is based on the general model of organisational information processing and control that comprises Component 2 (and

which is described in Chapter 3 above). This analysis can be applied to any type of industrial or commercial organisation regardless of the nature of the goods or services produced, the manner of their production, or the size of the organisation. The objective of this analysis is to produce a breakdown of the "total task" of an organisation (i.e. all the tasks that must be performed in the pursuit of the organisation's objectives) in such a way that the objectives given in Component 3 can be made operational. This method of organisational analysis is set out in ten stages, as follows:

Stage 1. Identify the operating systems of the organisation and their current work methods.

The products (or services) that are created and the manner of their creation are analysed. The assumption is made at this stage that, given the business that the enterprise under analysis is engaged in, the individual operating tasks that have to be performed can be completely specified. No assumptions are made concerning how individual operating tasks should be combined into jobs in ways other than those currently in existence. In a large organisation there will be a number of different types of operating system; the analysis at this stage is concerned solely with the "operations" of each of these, i.e. with what Ansoff calls the "logistic" processes. (See Figure 3.1 above, p.268.)

Stage 2. Identify the control factors of each operating system.

Some of the control factors that arise in production systems have been mentioned above (such as amount of material wastage,

throughput or processing times, product quality, output, operator efficiency and so on). In a hotel the control factors would be entirely different but might include supplies of clean linen, amount of dust in bedrooms and public rooms, stocks of alcohol, quality of meals, speed of service in the dining room and so on. At this stage all control factors are listed, not just what appear to be the more important or "key" control factors.

Stage 3. Analyse how the routine control operations for each control factor are carried out.

This may be done using the "routine control grid" which is illustrated in Figure 4.5. This analysis shows:

- (i) all the control factors relevant to each operating system;
- (ii) who (or what) measures the state of each factor;
- (iii) who compares the actual state of each factor with the standard;
- (iv) who decides the necessary corrective action;
- (v) who transmits this decision to the operating system.

By dealing with all the routine control operations for all control factors, this analysis should identify any gaps in an organisation's current control system, e.g. where information is not being passed on to the following control operation.

Stage 4. Analyse how the planning operations for each control factor are carried out.

This may be done using the "planning control grid" which is

ROUTINE CONTROL GRID*

CONTROL FACTORS	1	2	3	4	5	6	7	etc.....
CONTROL OPERATIONS								
Measurement								
Comparison								
Decide Action								
Take Action								

Figure 4.5: Suggested format of the Routine Control Grid.

*Note (1) A separate grid is to be used for each operating system.
 (2) Examples of this grid in use are given in Chapter 5 below.

illustrated in Figure 4.6. This analysis shows:

- (i) who sets operating system performance standards;
- (ii) who measures the results of the routine control operations, and the sources of the available information;
- (iii) who compares what has actually happened with what should have happened;
- (iv) who decides the necessary corrective action (i.e. action to alter the way in which the operating system functions or the way in which routine control is carried out);
- (v) who transmits this decision to the routine control function.

By dealing with planning related to all control factors, this analysis should again identify any gaps in an organisation's current control system, e.g. where information concerning performance is not readily available. In completing the planning control grid, it may be useful to group control factors in such a way as to reflect strong interdependencies.

Stage 5. Analyse how primary decisions are made.

This may be done using the "primary decision making grid" which is illustrated in Figure 4.7. This analysis will show:

- (i) who measures the results of the planning for all the operating systems in the organisation;
- (ii) who compares these results with the overall objectives of the organisation - trying to survive in the business of making product X with Y amount of resources;

PLANNING CONTROL GRID*

CONTROL FACTORS / CONTROL OPERATIONS	1	2	3	4	5	6	7	etc.....
Information Sources							
Set Standards							
Measurement							
Comparison							
Decide Action							
Take Action							

Figure 4.6: Suggested format of the Planning Control Grid.

- *Note (1) A separate grid is to be used for each operating system.
- (2) Examples of this grid in use are given in Chapter 5 below.
- (3) "Information Sources" are recorded on this grid for convenience; this is not a separate control operation.

PRIMARY DECISION MAKING GRID

		PRIMARY DECISION FACTORS	
		Products	Resources
CONTROL OPERATIONS	Measurement		
	Comparison		
	Decide Action		
	Take Action		

Figure 4.7: Suggested format of the Primary Decision Making Grid.

- (iii) who decides the necessary corrective action (i.e. action to change the nature of the organisation's business or to adjust the amount of resources with which it is conducted);
- (iv) who transmits this decision to the planning function.

Once again this analysis should indicate any shortcomings in an organisation's existing control system.

Stage 6. Analyse how coordination between the routine control functions of each of the operating systems is carried out.

This may be done using the "coordination grid" illustrated in Figure 4.8. This analysis shows:

- (i) who transmits information concerning each control factor to the routine control functions of other operating systems;
- (ii) who monitors information received from other operating systems.

The coordination grid lists all the control factors of each operating system whether information about each of them is provided to other routine control functions or not. This analysis can then be used to identify gaps in an organisation's existing coordination arrangements at the routine control level.

Stage 7. Analyse how coordination between the planning functions of each of the operating systems is carried out.

This analysis is conducted in precisely the same manner as that described above in Stage 6 concerning coordination at the routine

COORDINATION GRID

OPERATING SYSTEMS	Information from other operating systems			Information to other operating systems		
	A.	B.	C.	A.	B.	C.
CONTROL FACTORS*			etc....			
1.						
2.						
3.						
etc.						etc....
...						
...						
...						

Figure 4.8: Suggested format of the Coordination Grid.

*Note; all control factors arising in all operating systems should be listed.

control level.

Stage 8. Analyse how information concerning the organisation's environment is collected and used as input to the control operations at all levels.

This may be done by considering each control factor of each operating system and examining the types of information that may have to be obtained from outside the organisation in order to make effective decisions concerning each of those factors. The sales department, for example, may be responsible for maintaining a certain level of sales. In setting that level (a planning decision) information will be required concerning current and projected demand for the product, current and projected output from competitors, competitors prices, product substitutability, changes in consumer tastes and so on.

Stage 9. Analyse how information concerning the organisation is transmitted to the organisation's environment.

This may again be done by considering each control factor of each operating system and examining the types of information that may have to be transmitted to the organisation's environment in order to ensure effective overall control of each of those factors. In order to maintain adequate stocks of suitable quality components, for example, suppliers may have to be informed of production requirements in advance.

Stage 10. Produce job and organisational design proposals.

The analysis is now complete and provides two types of

information:

1. The analysis provides a comprehensive breakdown of all managerial and non-managerial tasks currently performed in an organisation, and indicates who performs these tasks.
2. The analysis identifies any managerial tasks that should be but which are not being performed.

This analysis can, therefore, be used in two ways:

1. To identify and repair any flaws in an existing organisational control system.
2. As a framework for change in job and organisational design.

The second of these uses is the main concern here, and this is treated in more detail in the following section.

Job and Organisational Design

The ten-stage method of organisational analysis described above thus provides an appropriate framework for the development and implementation of job and organisational design proposals. In other words it provides a framework for making job design objectives operational. Job design, it has been suggested here, generally takes place at the interface between managerial and non-managerial tasks. Job design thus invariably entails the transfer of routine control tasks previously performed by managers to either individual operators or groups of operators. In one of Herzberg's (1968) examples, the quality of operators' (stockholder correspondents) letters was originally checked by management (supervisors) before posting. The job enrichment scheme relaxed this monitoring arrangement and operators began to check their own letters. The control

factor concerned in this example is quality of reply to stockholders' questions. Previously, after the operator had written the letter, the manager would read (measure) it, check it for inaccuracies (compare), decide whether or not it should be reworked (decide), and ask the operator to do so if necessary (take action). Job enrichment gave to the operator all four routine control operations for this particular control factor. The manager in this case maintained some involvement in routine control; 10 per cent of all letters had still to be checked for accuracy in place of the previous 100 per cent check.

The analysis described above thus indicates how operators or groups of operators can be given additional responsibility. Operators can be asked to perform parts of the routine control of one or more control factors; they could be asked to perform the measurement and comparison stages, leaving decision making to the manager. Operators can, on the other hand, be asked to perform all the routine control operations for one or more control factors.

The analysis also indicates:

1. How job design changes of the type just described can be introduced gradually by asking operators to perform measurement and comparison operations and by gradually relaxing managerial support in decision making as operators become more confident. Operators can be given responsibility for one or two control factors at first, again increasing the number of factors controlled as confidence grows.
2. How these types of changes to the jobs of operators will affect the jobs of managers.

There are, therefore, various ways in which the job characteristic

"responsibility" can be made operational. The organisational analysis method described above presents a framework within which all the various options can be identified and considered.

The analysis described above also indicates how operators or groups of operators can be given more autonomy. In the stockholder correspondent example cited above, operators became involved in a routine control operation that had previously been performed entirely by management. But management still performed a ten per cent check on the work of the correspondents who, in sharing routine control in this way, were not fully autonomous in the sense of carrying out the entire routine control function for that control factor on their own. Autonomy can be increased, therefore, by withdrawing managerial supervision over the performance of the routine control operations. Gulowsen's (1971) scale of autonomy measures autonomy across a number of control factors (such as work methods, output, quality, hours of work and so on) but does not take into account variations in autonomy up the control hierarchy. How many "autonomous groups" exercise planning level control over the way in which their work is carried out, their output rate, and how their work as a whole is controlled? Where a group of workers do exercise planning level control over one or more control factors, they will invariably also exercise routine control over those factors.

The analysis described above also indicates how operators can be provided with feedback or knowledge of the results of their performance. Feedback of results does not imply that the operator measures his or her own performance, compares actual performance with standard, decides whether or not it is good enough and what action to take if it is not. Providing feedback simply implies that someone

- the operator, another operator, a manager - performs the routine control operations and tells the operator what action is required in order to improve performance in future. Once it is known how routine control decisions are taken, there is no great difficulty in arranging for these decisions to be transmitted to the appropriate operator or group of operators. Feedback of results can lead to improved performance; it was noted above that feedback is an essential component of the learning process. The provision of feedback, therefore, can provide operators with the opportunity to learn how to improve performance, to do the job more effectively. But as also noted above, this will not necessarily lead to continuous learning.

The analysis described above also indicates how operators can be given work that involves continuous learning. In order to provide continuous learning, either the operator must continually be given new tasks to learn, or he must be able to decide for himself how to alter the task that he is performing in order to improve overall performance in some way. In other words the operator must either be given new plans (i.e. sets of instructions) to perform, or he must be able to decide for himself how the current plan could be adjusted in order to improve performance of the higher order plan within which the current plan is nested. The former course of action, moving operators from one operating task to another, is akin to job rotation. The success of this measure in providing continuous learning will be dependent upon the types of task that the operator is rotated through. Job rotation tends to be used where individual tasks are fragmented and monotonous and any learning that takes place is thereby limited. If work is to provide

continuous learning, therefore, operators must be given information feedback that permits evaluation of the success of the current plan, and must be allowed to alter that plan if things appear to be going wrong or if performance could be improved.

An approach to the provision of continuous learning in work may be made by creating autonomous groups of operators that is groups which perform the entire routine control function for their operating systems. The "plan" for this group of workers is now "to operate and exercise routine control over the operating system"; the "skill" that the group now has to learn is "the operation and routine control of an operating system". This only partially meets the requirement that jobs should provide continuous learning. Operators can only alter the operating system to a limited extent because the routine control function is constrained by the decisions taken at the planning level. Planning establishes the performance standards that the routine control function is expected to maintain. If operators performing the routine control function suspect that these standards are inappropriate, they can only transmit relevant information to the planning level and await a decision. Opportunities for continuous learning will, therefore, be greatly enhanced where operators exercise control at both the routine and the planning control levels. The tasks of both the operating system and the routine control function are essentially "sub-plans" within the higher order plan for the functioning of the enterprise that is established at the planning level of control. It is at the planning level that the methods of working in the operating system and the methods of performing routine control are decided. It is now possible to state a general proposition concerning the nature of

continuous learning: continuous learning will only occur where the plan (set of instructions) that is being performed is part of a higher order plan (higher order set of instructions) and where the person or persons concerned perform not only the operating tasks that are involved but are also responsible for determining the contents of both orders of plan.

In order to provide continuous learning in work, therefore, operators must be allowed to perform the routine control and planning functions. To give operators control of primary decision making is not necessary to the provision of continuous learning, but this measure would expand the area of involvement of those concerned and thus expand the opportunities available. These proposals have three major implications for organisational design:

1. There will be an upper limit to the size of a group of operators that can carry out the routine control and planning functions as one cohesive unit.

It may be possible for the operators in separate operating systems within one large organisation to work in this manner, perhaps leaving the coordination tasks to those who previously acted as supervisors. This proposal is similar in intent to that of Schumacher who argues that in designing organisations, "The fundamental task is to achieve smallness within large organisation" (Schumacher, 1973, p.228). The "first principle" of what Schumacher terms his "theory of large-scale organisation" is the "principle of subsidiary function", which states that for higher levels to perform certain functions rather than lower levels, on the assumption that the higher level will automatically be

qualified to perform them better, "... is an injustice and at the same time a grave evil and disturbance of right order" (Schumacher, 1973, p.230).

The theory developed here indicates how smallness can be achieved within large organisations. But where groups of operators perform routine control and planning functions, there will be an upper limit to the number of operators within one operating system who together can deal with all these tasks. This limitation in turn places a constraint on overall organisational size.

2. If an organisation is designed in such a way that operators perform all the control tasks up to and including those of the planning level, then those operators will be responsible for the design of their own jobs - for the way in which they perform the operating and routine control tasks and for the way in which these tasks are allocated to the operators themselves. One aspect of organisational functioning that these operators will now be required to learn will concern the most effective design of their own jobs. The "design of jobs" is an inseparable part of the process of organisational design.
3. The procedures that the conventional organisation uses to obtain, record, disseminate and store information relevant to the control process are unlikely to be appropriate in an organisation designed along the lines proposed here. An information system must be designed that presents the information required in a format that makes it available

to all those who will have to use it. Control information will be used by groups of operators for different control functions and the means by which is obtained and presented must take account of this. The design of information systems is, therefore, a fundamental part of organisational design.

To summarise briefly, there appear to be three major consequences that arise when groups of operators perform all control tasks up to and including those at the planning level:

1. there is an upper limit to the number of operators that can effectively control one operating system as a group;
2. this type of organisational design obviates the need for detailed design of jobs;
3. this type of organisational design emphasises the need for the design of appropriate information systems.

The Learning Organisation

Two major themes of both empirical and theoretical studies in organisational behaviour have concerned (a) the development of human potential through work, and (b) the ability of organisations to cope with a changing environment. The first of these concerns, the development of human potential, has attracted the interest of numerous writers, including Herzberg (1966), Argyris (1957), McGregor (1960), Likert (1961) and Schein (1970). These writers hold two basic assumptions in common. First, that man has an innate desire for growth in competence; Herzberg (1966) refers to the process of "psychological growth", Argyris refers to the

tendency to develop towards "maturity". Second, that this human goal is not inconsistent with the goal of organisational effectiveness. The writers cited above offer various prescriptions for fulfilling both of these goals simultaneously, principally by changing managerial style, or by redesigning jobs.

The ability of organisations to cope with a changing environment is a second area of concern in the study of organisational behaviour. Burns and Stalker (1961) for example argue that an organisation facing changing technological and market conditions will find conventional management systems inappropriate and suggest that an "organic" system of management is more appropriate. An organic system of management is more flexible, less hierarchical and has a lower degree of work specialisation than the "mechanistic" system with which it is contrasted by Burns and Stalker. Miller and Rice (1967), whose work is discussed above (pp.157-173), similarly argue that organisational effectiveness is influenced by the relationship between market forces and organisation structure. They conclude that if an organisation is to be capable of adjusting to environmental changes, organisation structure should allow for periodic rearrangements of personnel. To this end they prescribe a "project type organisation" in which personnel possessing appropriate skills and knowledge are brought together to perform specific tasks and are disbanded to join other new groups as the original task or tasks disappears and new circumstances require new groupings of personnel. Permanent groupings, argue Miller and Rice, generate resistance to change which the project type organisation attempts to overcome.

The respective prescriptions of Burns and Stalker and of Miller

and Rice are directed at developing organisational flexibility in the face of novel environmental circumstances and pressures. Both sets of authors, however, claim that their prescriptions will not necessarily apply to organisations fortunate enough not to have to constantly react in this way to external influences. Burns and Stalker thus suggest that the "mechanistic" system of management may be appropriate for organisations whose environment is reasonably stable. Similarly, Miller and Rice suggest that permanent employee groupings may be a satisfactory organisational solution where environmental stability can be assured.

The techniques that have been suggested for improving the development of human capabilities through work are not necessarily consistent with the organisational goal of flexibility in dealing with change. Conversely, organic systems of management or project type organisations are not necessarily consistent with the development of human potential. An organisation that is capable of improving performance in both of these areas simultaneously may be designated a "learning organisation". This type of organisation will continue to find ways of improving performance of the primary task or tasks of the organisation, and it will continue to improve the capabilities of its members. It has been suggested above that the optimum organisational design solution is that where the group of operators in an operating system perform all the necessary operating tasks and control tasks up to and including planning. It is further suggested, therefore, that this design solution approaches the criteria for a "learning organisation". The operating group becomes a self-regulating, learning unit; the unit will be able to develop better

operating methods, better methods of controlling operations, and will be able to provide its members with work that possesses a number of desirable characteristics such as opportunity for continuous learning, feedback, responsibility, autonomy and social interaction opportunities.

This prescription is clearly idealistic and not easily achieved. The first stage in developing some of the above ideas was to find out if the general model of organisational control does indeed provide a suitable framework for organisational analysis and design. In the Chapter that follows, Chapter 5, two organisational case studies are described in which an attempt is made to answer that question.

CHAPTER 5:

TWO CASE STUDIES IN THE ANALYSIS OF
ORGANISATIONAL INFORMATION PROCESSING
AND CONTROL.

TWO CASE STUDIES IN THE ANALYSIS OF ORGANISATIONAL
INFORMATION PROCESSING AND CONTROL.

Introduction

Towards the end of Chapter 4 above, a ten-stage method of organisational analysis was described. It has been argued that this type of analysis, concerned principally with organisational information processing and control, is an appropriate framework for examining job and organisational design choices. The purposes of this Chapter are: (a) to describe how this analysis was applied to the production control systems of two manufacturing units, and (b) to show how the results of this type of analysis can be used to generate job and organisational design options and to examine their effects.

This method of analysis is based on the general model of organisational information processing and control described in Chapter 3, and incorporates the following ten stages (these are described in detail above):

1. Identify the operating systems of the organisation and their current work methods.
2. Identify the control factors of each operating system.
3. Analyse how the routine control operations for each control factor are carried out.
4. Analyse how the planning operations for each control factor are carried out.
5. Analyse how primary decisions are made.

6. Analyse how coordination between the routine control functions of each of the operating systems is carried out.
7. Analyse how coordination between the planning functions of each of the operating systems is carried out.
8. Analyse how information concerning the organisation's environment is collected and used as input to the control operations at all levels.
9. Analyse how information concerning the organisation is transmitted to the organisation's environment.
10. Produce job and organisational design proposals.

To conduct a complete and detailed analysis of even a small organisation using this method is a large task. To test the validity of the method, the analysis was restricted to one type of operating system - production systems - providing comparable evidence of the method's value in different industrial settings. The advantages obtained through this approach are offset by the lack of attention paid in each case study to coordination between the production system and other operating systems, and to the organisation's information exchange with its environment. After a brief description of the production (i.e. operating) tasks of the manufacturing units studied, the analyses concentrate on the operations of the basic control hierarchy, that is with routine control, planning and primary decision making concerned with each production system studied.

It is hoped that by presenting the first case study in some detail, the method of analysis is illustrated to a degree that permits a briefer description of the other case study*. Both case studies will

* A third case study is presented in Appendix IV. It is not included in this Chapter because the pattern of results is similar to that obtained in the studies described here.

be described before examining the implications of their results in terms of job and organisational design.

Conduct of the Case Studies

The production systems and production control methods of three manufacturing units were studied: a factory belonging to Ferranti Ltd., making precision electronic components, and two factories of Wilkie and Paul Ltd., in Edinburgh, making tin containers and vacuum formed plastic items respectively. Each case study took place in two stages. First, a preparatory phase was undertaken that involved obtaining background knowledge of the production methods of each company. This preparatory phase covered the first two stages of the analysis - identifying the operating system and the relevant control factors. Regular visits to each factory were necessary to complete this phase. By meeting and talking informally to the staff of the respective production departments an understanding of each company and its manufacturing processes was obtained. The relationships that were established with the staff in the production departments at this stage greatly facilitated the work that followed.

The second phase of each case study involved interviewing all personnel above operator level in the production department being studied. These interviews were carried out in private and in each case in an office provided by the company concerned, away from the noise and constant interruptions that generally prevent prolonged conversations on the shop floor or in individuals' regular offices. The purpose of these interviews was to discover how the various control operations were carried out. A tape recorder was used (only one respondent refused to be recorded but permitted notes to be taken)

and a transcript was made of the relevant information before erasing the tapes. The interviews were semi-structured and examples of the types of questionnaires used are given in Appendix IV. The production personnel were asked questions about their job and specific questions about their involvement in certain aspects of production control. Inferring from their replies who performs which control operations and how is a fairly straightforward task; a complete transcript of one interview is also given in Appendix IV which illustrates this process of inference in some detail.

It should be noted that these analyses deal with the "normal" production operations of the companies studied. Certain exigencies naturally require special procedures for their control, analysis of which would require lengthy and complex description that is not directly relevant to the purpose in hand. Any definition of "normal" however, must be subjective; it is taken here to mean what the production personnel in each case regard as normal. The parameters of production performance are expected to vary within limits which when exceeded present the company with an "abnormal" situation that requires exceptional control procedures. Such an abnormal variation arose during the first case study. The material being used in the manufacture of a particular component began to exhibit unusual properties and 90 per cent of production of that component had to be scrapped. The normal routine control operations were unable to deal with such a problem and large numbers of people were involved in finding a solution. Such occurrences are infrequent and are to some extent unique, and the analysis carried out does not attempt to cover them.

1. CASE STUDY I : FERRANTI'S ROTATING COMPONENTS GROUP

The first company that was approached in connection with this research was the Rotating Components Group of Ferranti Ltd. The Rotating Components Group operates from a factory on an industrial estate near Dalkeith, about five miles south-east of Edinburgh.

Ferranti Ltd. employs over 20,000 people in factories, laboratories and offices in the United Kingdom, Canada, U.S.A., Republic of Ireland, Germany, Italy and Austria. Their first Scottish factory was opened in 1943 at Crewe Toll in Edinburgh to manufacture gunsights. After the war, the increase in demand for electronic products prompted an extension of their activities in this field. The size of the factory at Crewe Toll has been increased several times and other factories have been built in Edinburgh, Dundee, Dunblane and at Dalkeith. In Scotland, Ferranti is the largest single company in the electronics industry and employs well over 6,000 people.

The factory at Dalkeith was opened in 1963 and now houses the Measurement and Inspection Department and the Rotating Components Group. These two divisions operate independently and it is with the latter that the research was carried out.

The Rotating Components Group

The organisation chart of the Rotating Components Group is shown in Figure 5.1. This Group is actually a part of Ferranti's "Inertial Systems Department" and the General Manager of the Rotating Components Group reports to the General Manager of that Department. The responsibility of the Rotating Components Group's General Manager

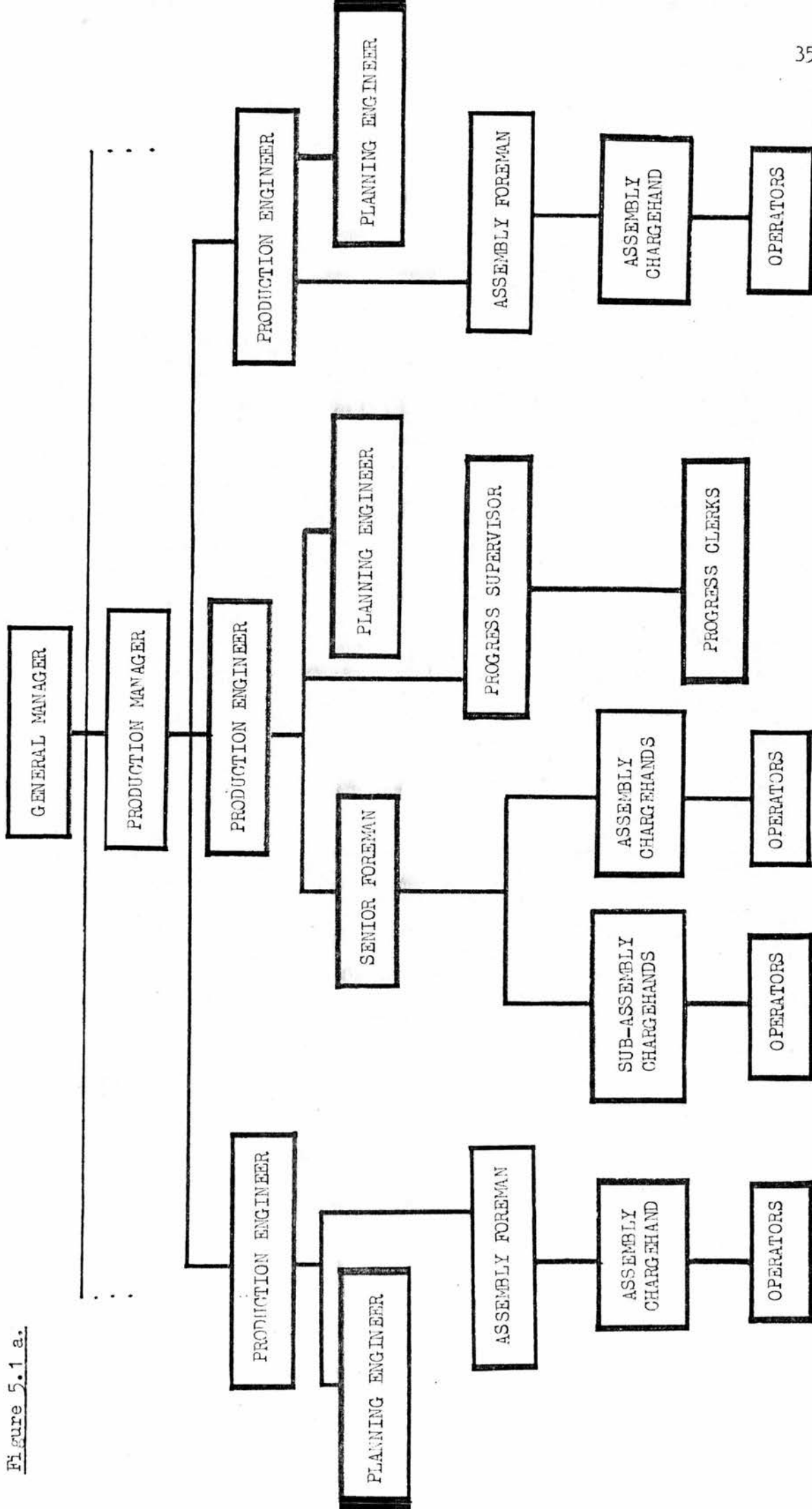
Figure 5.1: Organization chart of Ferranti's Rotating Components Group.

5.1 a shows the organization of the production sections.

5.1 b shows the quality, design and sales departments.

The Group's Administration Department has been omitted from these charts for convenience. This does not affect the analysis.

Figure 5.1 a.



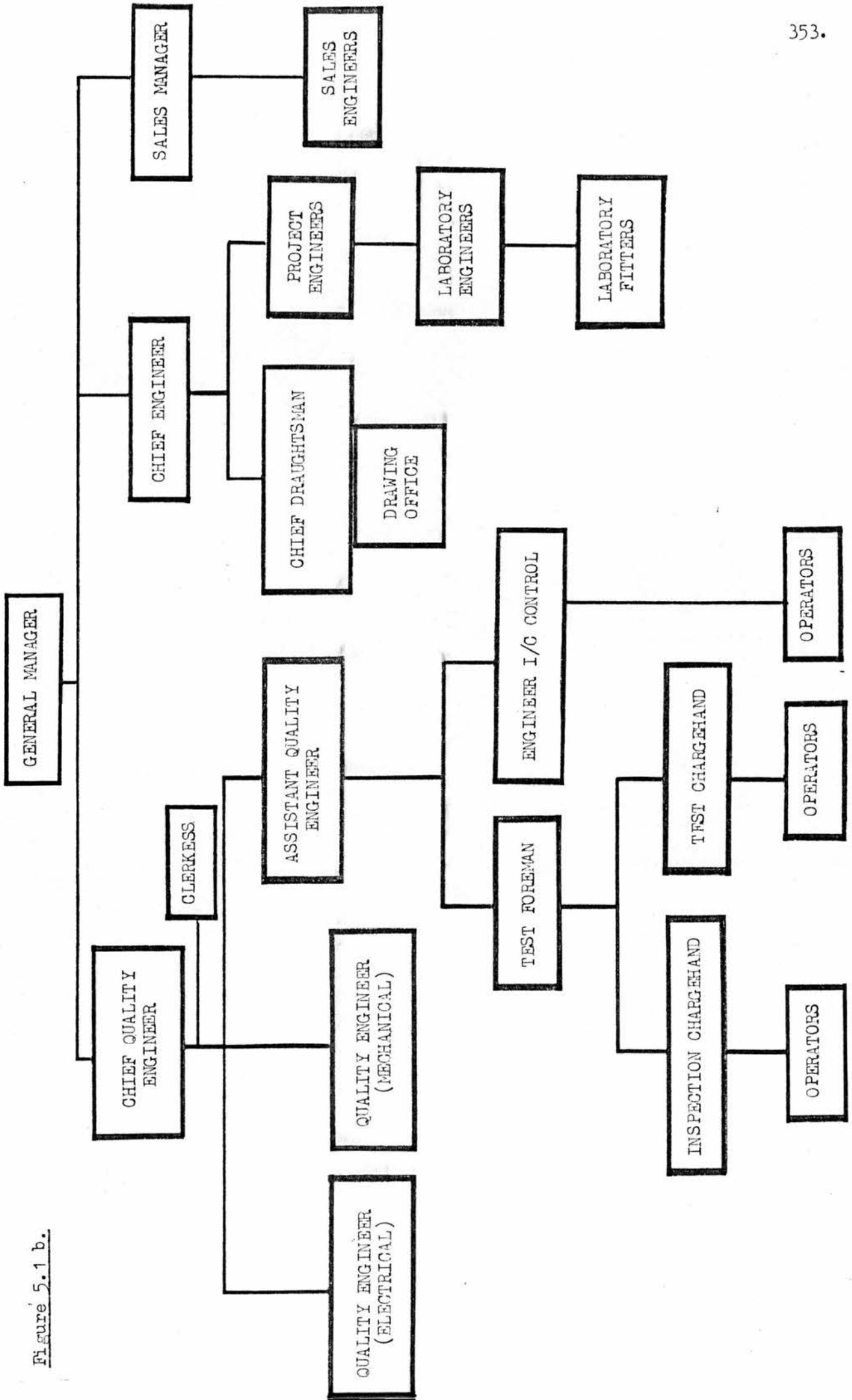


Figure 5.1 b.

falls into five main sections: Production, Quality, Design, Sales and Administration. The following are outwith his direct control but are provided to the Group as "central services": Machine Shop, Stores, Despatch, Work Study, Personnel, Cost and Wages Departments. It was not possible to collect detailed information concerning the operations of these other Departments, whose staff is ultimately responsible to superiors in other parts of the company.

Products and Markets

The Rotating Components Group employs over a hundred people and is principally concerned with the manufacture of a wide range of precision electronic components with an annual turnover of approximately £1 million. A proportion of this turnover goes to other Ferranti units but outside commercial concerns provide an expanding market for the Group. The current range of rotating components includes precision potentiometers, optical shaft encoders, miniature a.c. motors and a variety of gyroscopes. Within these major product groups, however, there is an enormous range of possible variations with no two customers requiring the same specifications for their products. For example, potentiometers, being components which "rotate", have a central shaft. Two potentiometers may be identical in every respect except for the length of this shaft. The number of different specifications, for all products, is roughly 3,000, and the Group manufactures almost exclusively to order. The differences may be negligible or fundamental, but consequently each item must be individually identified on the shop floor, once its assembly has begun. The paperwork which accompanies items through the production process caters for this and is described below.

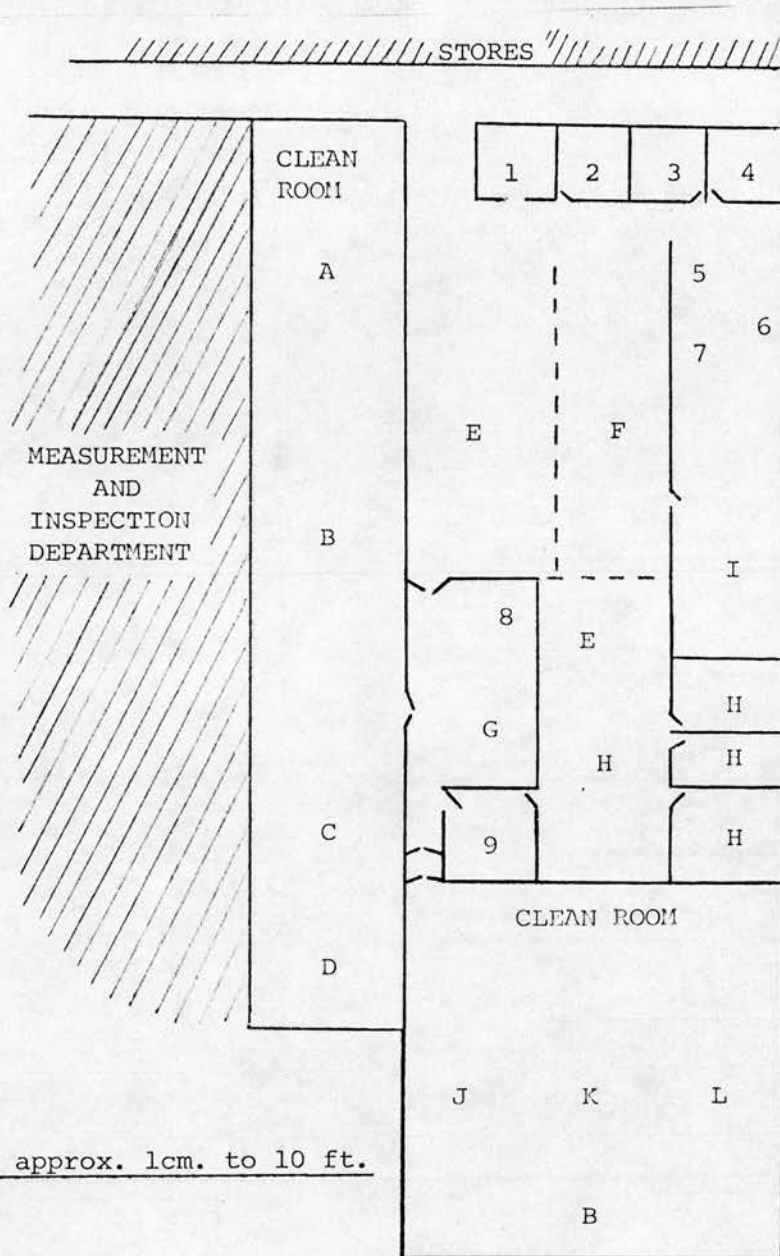
The output of potentiometers accounts for 50 to 60 per cent of the total; these are used extensively in airborne systems, analogue computers, radar equipment, simulators, industrial process plant and machine tool control systems. The range of motors manufactured is used in aircraft, missiles and professional equipment. Gyroscopes are used mainly for "in-house" applications such as the airborne navigation systems manufactured at Crewe Toll. For some of these products, this factory is the sole source of supply.

All the final stages of assembly and testing of these components are performed in two "clean rooms" which are subject to temperature and humidity control. There are also a number of regulations designed to control dust in these rooms. Anyone entering either of the rooms must wear a nylon overcoat, and in the larger room, a nylon hat must also be worn. Certain operations, such as filing of metal, cannot be done in these rooms, and some materials may not be used in case they shed contaminating fragments. A very small particle entering one of these highly sensitive components may render it useless, and this could be fatal if the component is in use, say, in an aircraft. The sub-assembly and intermediate inspection stages are carried out under less stringent conditions outside the clean rooms, but here too cleanliness is important.

Manufacturing Facilities

The layout of the Rotating Components Group's manufacturing facilities is shown in Figure 5.2. The layout is determined essentially by process, although similar processes for different products are carried out in different areas (e.g. windings for potentiometers and for motors; final assembly of gyroscopes and

Figure 5.2: Layout of the Rotating Components Group's manufacturing facilities.



Scale: approx. 1cm. to 10 ft.

- A: H/L Potentiometer Assembly.
- B: Final Test Section.
- C: Potentiometer Winding Room.
- D: Motor Winding Room.
- E: Inspection Section.
- F: Female Sub-assembly.
- G: Changing Room.
- H: Processing and Fitting Section.
- I: Progress Section.
- J: General Potentiometer Assembly.
- K: Gyro and Motor Assembly.
- L: Encoders Assembly.

- 1: Quality Engineer (Mechanical).
- 2; Chief Quality Engineer's Office.
- 3: Assistant Quality Engineer's Office, and one Production Engineer.
- 4: Office of other two Production Engineers.
- 5: Quality Engineer (Electrical).
- 6: Planning Engineers.
- 7: Engineer I/C Control.
- 8: Timekeeper.
- 9: Office of Test Foreman, Senior Foreman and two Assembly Foreman.

of encoders).

The Group's labour force is divided in the following way:

There are four sub-assembly sections which produce the component parts used in the final products. Although the final products may all be different, many of them use common sub-assemblies or component parts. Each section is supervised by a chargehand who sits at a desk in the area. Figure 5.3 gives a brief description of the function and composition of each of these sections.

There are four final assembly sections, described in Figure 5.4. In these sections, each Operator builds the product from the sub-assembly stage to the finished item. The work is done by hand, with the use of some special tools or "jigs and fixtures". A high degree of manual dexterity is required of the Operators, and some have been recruited from the watch-making trade where similar skills are required.

There is one Inspection Section and one Final Test Section. The former carries out the inspection of all finished sub-assemblies, and performs intermediate inspections during the build-up of final assemblies. Most of this work involves making only a visual check, sometimes with a microscope, on the quality of the item. In the Final Test Section, finished products are tested to ensure that they are fit for all the uses to which they will be put, before being despatched to the customer. Each Operator is responsible for the test of one item, or batch of items, at a time, and the testing is carried out on special rigs which are used to monitor certain performance characteristics of the products. A summary of the functions and composition of these sections is given in Figure 5.5.

There is also a Progress Section responsible for issuing jobs to each section on time and in the required sequence. This is

Section Name	Functions	Number of Operators		
		Male	Female	Total
Potentiometer Winding Room	winding wire onto formers	0	5	5
Motor Winding Room	winding wire onto coils	0	5	5
Processing and Fitting Section	various laminations etc; make jigs and fixtures	9	1	10
Female Sub-assembly	all other sub-assembly work	0	9	9

Figure 5.4: Final assembly sections.

Section Name	Functions	Number of Operators		
		Male	Female	Total
H/L*Potentiometer Assembly	mainly general assembly on potentiometers, but with some sub-assembly work	0	11	11
General Potentiometer Assembly	main assembly of potentiometers	9	0	9
Gyro and Motor Assembly	main assembly of MarkVI gyro, integrating and rate gyros, and various motors (e.g., blowers and pumps)	7	0	7
Encoders Assembly	main assembly of encoders, but with some sub-assembly work	5	0	5

* High Linearity - a type of potentiometer

Figure 5.5: Inspection and Test sections.

Section Name	Functions	Number of Operators		
		Male	Female	Total
Inspection Section	inspection of all completed sub-assemblies and intermediate inspections for final assemblies	0	9	9
Final Test Section	final electrical testing of all finished products	6	5	11

achieved through a complex paperwork system operated by three male and four female Progress Clerks. The Progress Supervisor takes charge of the running of this section.

These eleven sections make up the production system or operating system under analysis.

Stage 1 of the Analysis : The Tasks Involved in the Manufacturing Process

Although the Production and Quality Departments in the Rotating Components Group are shown separately on the organisation chart (see Figure 5.1), together they constitute one operating system within the factory - the production system. In the words of the Group's General Manager, they constitute the factory's "assembly machine"; each section operates rather like a position on a conventional assembly flow line where products move through various assembly stages passing a number of inspection points on the way, and a final test at the end.

To illustrate how the factory operates, the manner in which an individual order is processed, from the time it is placed to despatch to the customer, will be examined. This description will apply to the manufacture of any of the Group's products. An outline of the materials flow through the production process is given in Figure 5.6.

The Sales Department receives the order, say for four potentiometers. Unless it is a repeat order, the Design Department will be asked to scrutinise the customer's requirements to ensure that the product can be made by the Group. Having been thus vetted, the Sales Department sends the order to the Production Engineer responsible for potentiometers who will quote a delivery date. The customer

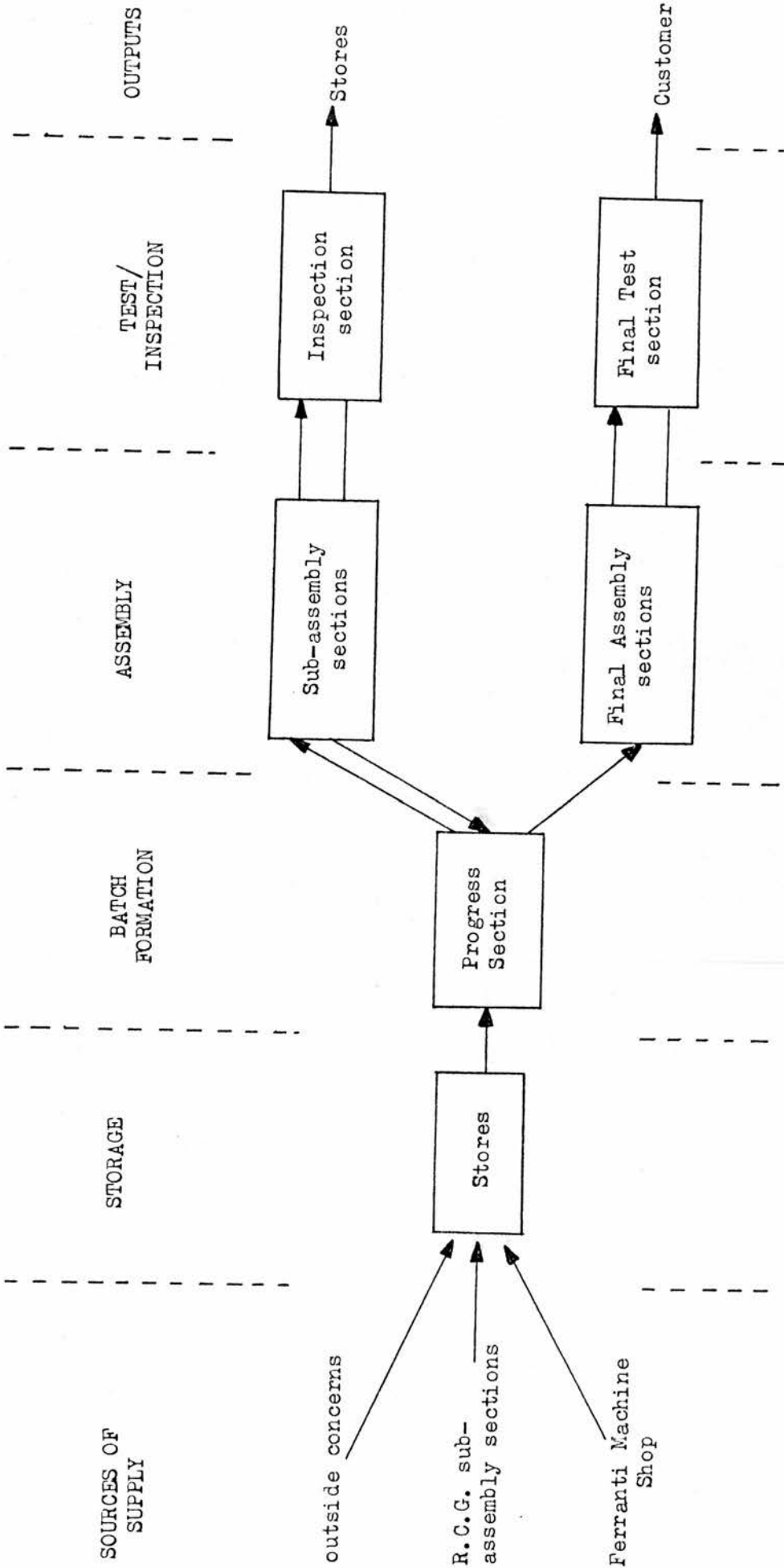


Figure 5.6: The Rotating Components Group's production process.

will be told this if necessary, but usually the Sales Department know from experience whether it will be suitable or not. If the order is to continue, the Design Department produces a set of drawings for the new potentiometer. A copy of this drawing is sent to the Planning Engineer responsible for potentiometers. He compiles a list of step-by-step instructions itemising all the operations necessary to build the product. He may also have to design new instruments or appliances - "jigs and fixtures" - to facilitate the assembly process. These will be made in the Processing and Fitting Section, one of the sub-assembly areas. The list of instructions is typed by a Progress Clerk onto a "route card", a master copy of which is retained in the Progress Section. The route card accompanies the potentiometers from the sub-assembly stage through to the finished product and serves to identify these particular items from others on the shop floor. It is unlikely that any new specifications be required of the sub-assemblies. If this was the case, the Planning Engineer would draw up a similar list of instructions for their manufacture and these would proceed as any others through the appropriate sub-assembly section. Another copy of the initial design drawing is filed in the main assembly section for use by the Operator whose task it will be to assemble those potentiometers.

A copy of the order is sent to the Progress Section. The delivery date on the order is converted into a "period number" which indicates when the items must be ready to despatch to the customer. This number is stamped on the top right-hand corner of each route card. The year is divided into periods each containing one working week. Normally, one week will equal one period, but

the two weeks holiday in July when the factory is shut, plus the working week following, equals one period. The current period number is displayed on boards that all sections can see. Thus it is possible at a glance to decide whether any batch is ahead of schedule, on schedule, or "in lag", i.e. late. The route cards accompanying the jobs in each section are stacked in order of period number with the lowest number at the front. When Operators finish the job they are doing, they are normally given the route card, and job, at the front of the queue. The Chargehand must see that this is done. Occasionally, an Operator may not have enough experience to tackle the first job available and the Chargehand must then find an easier job from further back in the queue. Ideally, however, the job which must be delivered first should be started first. This method of progressing jobs is referred to as the "period batch system" and it applies to all the production, inspection and test sections in the factory.

Sub-assembly Stages:

The Progress Section has compiled a "master parts list" for each product. This is simply a list of all the parts and materials that go into the product. Some of those must be put together before going into the final item, and many of these "sub-assemblies" are common to different products within each product group. All potentiometers, for example, require " housings", "wipers" and "formers". If the only difference between two potentiometers is their shaft length, they will both use the same type of former, housing and wiper. These parts are put together in the sub-assembly sections. Knowing the due date for the job and how long it will take

to complete all the sub-assembly stages, the Progress Clerks calculate when to issue each part of the job to the appropriate sub-assembly section. They calculate the period in which each stage must be completed and this is stamped on the top of the route card. There will be other potentiometers requiring sub-assemblies besides the four we are interested in. The route card may accompany a batch of up to 20 items. Sub-assemblies are usually small, easily carried around, require minimal storage space and are completed in comparatively short periods of time; (The Progress Section usually allows one week for the manufacture of each batch). For these reasons, the batches may be larger than in final assembly.

A Progress Clerk requisitions the parts and materials for the sub-assemblies and puts them into a plastic box, appropriately labelled, rather like a child's construction kit. The Progress Clerk takes these to the sub-assembly section where they are placed in bins, and the route cards are arranged in period number sequence. As Operators finish the jobs they are doing, they are given the jobs from the front of the queue. Each Operator works on a complete batch until it is finished. Most of the work is done by hand and is comparatively simple. Wire is wound onto coils and formers by machine; parts have to be glued together, terminals must have leads soldered to them; small parts may have to be cleaned and varnished.

In the period when an item must begin its final assembly stages (if it is to be finished on time) all the sub-assembly stages must be complete. The Inspection Section must have checked all the sub-assemblies and passed them as suitable, i.e. as conforming to the inspection schedules which are drawn up by the Quality Engineer (Mechanical). The schedule is a list of instructions telling the

Inspection Operator what to look for and when to reject an item. It may be possible to repair or "rectify" defective items. This is normally done by the Assembly Operator responsible. Many components made at the sub-assembly stage are reasonably inexpensive and it is often cheaper to scrap defective items. Some are inevitably irreparable and must be scrapped anyway. The fact that a certain percentage of each batch of sub-assemblies will be scrapped is taken into account by the Progress Clerks when making up the batches. The "scrap factors" which are used were calculated some years ago, however, and there is no statistical analysis performed at present to up-date these estimates. If they have been revised, it has been by subjective judgement. All information concerning the start and finish times of each batch, the batch size and the percentage of scrap produced is recorded in the "issue books" kept by the Progress Clerks. This record is used mainly for reference.

Final Assembly Stages:

Having ascertained that the requisite sub-assemblies, parts and materials are available, the Progress Clerk issues these, as with sub-assemblies, to the appropriate section which in this case would be General Potentiometer Assembly. The quantity of work, or "loading", of each section is decided by the Production Engineer in conjunction with the Progress Supervisor. The Work Study Department compute standard times for each job which are used in operating the bonus scheme. The Production Engineer can calculate how many man-hours he has available in any one month. From the issue books, the amount of work in progress in each section is tallied and the available capacity for that month, in man-hours, can be shown. Using the estimated standard

times as a guide, and knowing the man-hours available, each section can be loaded for the coming month, and, to a lesser extent, for two or three months to follow. The Production Engineer must be aware of the loading in his sections because he has to quote delivery dates on incoming orders. Account must also be taken of the amount of "rectification work" which will have to be done. This refers to those items which have been rejected by Inspection or Final Test and have been returned for repair. This work will consume a significant proportion of the man-hours available.

The sub-assemblies and parts for each potentiometer are again put in a plastic box by a Progress Clerk who takes this to the assembly section with the route card which is placed in the queue of other potentiometer work, depending on its period number. At this stage, the four potentiometers will probably make up one batch. Finished items are bulkier than sub-assemblies and would be correspondingly more difficult to move around in batches of 20. Potentiometers are seldom more than a few inches long and storage is no problem. However, the throughput time of a final assembly is longer than that of a sub-assembly. So batches of final assemblies are never larger than five items. Should an order arrive for a large number of items, this will be broken down into several small batches.

The Chargehand in the section must give the job at the front of the queue to the first Operator available if that Operator is capable of doing the work involved. Sometimes this decision is a complex one; the Operator may be capable but the Chargehand may know that a different Operator would do the job quicker and better. The less capable Operator may require further experience and the Chargehand may give him the job for this very reason. If, however, that

particular job is "in lag" and the customer is an important one, the Chargehand will hold the job back for a more experienced Operator. He may have had instructions from a superior to this effect.

Once the Operator has the route card and the box containing the requisite parts, he will obtain the copy of the design drawing and commence assembly. It has been pointed out above that each job is given a standard time by the Work Study Department. Each Operator informs the Timekeeper, who sits just outside the clean rooms, when he starts and stops each job. This information is used in the calculation of bonuses. At certain points during the assembly of the potentiometers checks are made on the quality of the work carried out. The items are taken to the Inspection Section where the Inspection Operators check the items against the inspection schedule. If all the items in the batch pass this inspection they are returned to the Operator to continue assembly. If one or more items are rejected, these are returned to the Operator for rectification. The good items remain in the Inspection Section until the defective items have been rectified satisfactorily, then the whole batch returns to the Operator to continue assembly. Items may pass several times between final assembly and the Inspection Section. This may be for checks at subsequent assembly stages or because items have to return for rectification, perhaps more than once. The faults which arise are largely characteristic of the production of precision electronic components. The tolerances to which the Operator must work are frequently narrow and materials can exhibit remarkable variability in quality; errors due to careless workmanship are infrequent.

When the items are complete, they are taken to the Final Test Section where their performance is monitored on suitable test rigs.

If any of the items are rejected at this stage, they are again returned to the Assembly Operator to be rectified before returning once more to the Final Test Section. Items performing just outside the required parameters may be granted a "concession" if the customer is willing. The case is typical where an item in test fails to meet a stipulated performance parameter but is nevertheless capable of fulfilling the purpose for which it is required. The Sales Department frequently know from past experience with particular customers what is acceptable and what is not, but the customer will be informed if necessary.

When the four potentiometers pass Final Test successfully, or are granted a concession, they return to the final assembly section to be labelled, then go to the Inspection Section to have the information on the label checked. The items then go to the Despatch Department where they are consigned to the customer.

Stage 2 of the Analysis : Identification of Control Factors

The place of the Rotating Components Group in Ferranti's organisation structure means that certain control factors arising in the production system are controlled by other operating systems. This is true of labour and materials costs, quality of incoming materials and piece-parts, quantities of piece-parts in stock and on order, quality and speed of packaging and time taken to complete deliveries. The complete list of control factors arising in and controlled in the production department, and the sections in which these arise, is as follows:

Control factors	Sections
1. Group output	Final assembly
2. Throughput time	Sub-assembly
3. Throughput time	Final assembly
4. Throughput time	Inspection
5. Throughput time	Test
6. Quality of products	Sub-assembly
7. Quality of products	Final assembly
8. Quantity of scrap	Sub-assembly
9. Reject concessions	Final assembly
10. Methods of work	All assembly
11. Methods of work	Test and Inspection
12. Operator efficiency	Sub-assembly
13. Operator efficiency	Final assembly
14. Operator efficiency	Inspection
15. Operator efficiency	Test
16. Task allocation within a section	All assembly
17. Task allocation between sections	All assembly
18. Task allocation within a section	Test and Inspection
19. Task allocation between sections	Test and Inspection
20. Size of work force	All sections
21. Shop floor layout	All sections

Stage 3 of the Analysis : The Routine Control Operations

Before illustrating the use of the "routine control grid" that was suggested in Chapter 4 above, the routine control operations will be described in some detail. This case study is used to show precisely how the analysis works in practice and the next case study is presented in a much briefer format. The routine control of each factor is analysed in turn. The description of the routine control of each factor shows how the four control operations - measurement, comparison, decide action and take action - are carried out. The job-titles of the personnel involved in carrying out these control operations have been underlined; these are the names that are entered in the routine control grid. (The routine control grid is shown in Figure 5.7 on page 400, below.)

1. Group Output

Measurement:

The output of the Group is measured by a Clerk in the Administration Department who visits the Despatch Department three times a week to record what has been sent to customers since his last visit. The Cost Department also compiles a statement of turnover for the final accounts but this, while accurate, does not appear until the end of the month following that to which it refers. So the figures from Despatch are the ones used for routine control purposes: the output figure is converted into a percentage of the forecast monthly total output and the Administration Clerk compiles graphs of the output of each of the main product groups, along with a totals graph, and updates these weekly. Copies are posted in the Administration Department and in the Production Engineers' offices.

The records of the Progress Section, as with those of Despatch, could be taken to indicate output figures. These records are updated by information from despatch and may be inaccurate at any given time. They are used only for reference.

Comparison:

The Production Engineer in each section must quote delivery dates on all orders for his products and determine the loading of his section. If the forecast output is not being met, the Production Engineer must decide how serious the deviation is from his knowledge of the overall situation. Some superfluous operations on an inspection schedule may be holding up a number of expensive items. This could be corrected. If a third of the labour force is absent

with 'flu, the output achieved may be the best possible in the circumstances.

Decide Action:

If the Production Engineer does decide that output is lagging significantly and he can discover the reason, he will try to find out what can be done to remedy the situation. Sometimes, an individual job may have a noticeable effect on the total output figure and the Production Engineer must decide, in the event of some delay, what priority to give such a job. Parts from suppliers, or from the factory Machine Shop, may not have arrived. He must decide whether to call on the suppliers to hasten delivery, or attempt to obtain parts elsewhere. Sub-assemblies may have been delayed in one of the Group's own sections and the Production Engineer must decide what priority he can put on these if necessary.

Take Action:

If some job or jobs are to be given priority, the Production Engineer will inform the Foreman who will, in turn, instruct the Chargehand accordingly. The Chargehand must then give that job to the first Operator available. If suppliers or the Machine Shop have not provided ordered components, the Production Engineer will usually deal with them in person or instruct the Progress Supervisor to deal with the situation. If a Sub-assembly section has delayed the necessary components the Production Engineer will instruct the Foreman to ask the Sub-assembly Chargehand what can be done.

2. Throughput time, Sub-Assembly

Measurement:

The Sub-assembly Chargehands and Senior Foreman are able to see immediately that a job has not been completed on schedule by looking at the period numbers at the tops of the route cards. The issue books kept by the Progress Clerks give a historical record of the start and finish times of all jobs handled by these (and all other) sections. From this it is possible to compute the actual throughput time of any particular batch, but no statistical analysis is performed on these figures. This record is used only for reference. The Work Study Department calculates a standard make time for each job in connection with the bonus scheme. These figures are not directly relevant for measuring throughput time for two reasons. First, the calculations are performed in such a way as to allow most Operators to earn significant bonus by completing jobs in less than the standard time. Second, even allowing for this discrepancy, the calculation does not account for the multiplicity of delaying factors which affect the throughput times of jobs such as Operator error, material shortage, design faults, and so on. These figures may therefore be used as a rough indication of how long a job should take, but no reconciliation is attempted between theoretical and actual times.

Comparison:

The Sub-assembly Chargehand will often be the first to notice that a job has been delayed. Depending on why this has happened, the Chargehand may try to correct the situation, or, in a more serious

instance, inform the Senior Foreman. The Senior Foreman may discover such jobs for himself, if the Chargehand does not tell him, and if he feels that the case is a serious one, he will inform the Production Engineer. If a Progress Clerk notices that a parts or materials shortage will hold up some work, he will inform the Progress Supervisor if he believes that the situation warrants the latter's attention. The Progress Supervisor monitors the situation by checking the items he has in stock and on order, and by finding out when parts or materials will be delivered. If any of this information reveals a comparatively serious situation, the Production Engineer will be notified either by a Progress Clerk or by the Progress Supervisor.

Decide Action:

The Sub-assembly Chargehand will be able to solve a large number of problems which cause delays. Slow Operators may require further instruction; a job may be stopped to allow another to go ahead. The Senior Foreman is expected to handle more pressing problems of hold-ups, perhaps where a large number of costly items are delayed, or when an important customer is waiting. From his knowledge of the stock availability situation, the Progress Supervisor will decide whether to take any action in this area or not. He may contact the supplier; this may be an outside company, another Ferranti unit, or the factory Machine Shop. The required parts may have been "lost" in stores and the Progress Supervisor may decide to investigate this in person or through a Progress Clerk. The Production Engineer may decide that the delayed job, or jobs, be brought to the front of the queue, regardless of period number, in order that such jobs may be completed earlier. Neither the Senior Foreman nor the Chargehand can

take such a decision to override the period batch system.

Take Action:

The Sub-assembly Chargehand may be able to initiate action in person, or will undertake to do that directed by the Senior Foreman or Production Engineer. This will usually mean giving certain jobs to certain Operators, or giving particular jobs special priority and completing them as fast as possible. The Progress Supervisor might contact a supplier for undelivered materials or check the stores contents in case items have been mislaid or overlooked. A Progress Clerk may perform the latter task.

3. Throughput time, Final Assembly

Measurement:

An historical record of start and finish times of all final assemblies is given in the issue books kept by the Progress Clerks. The actual throughput time of any job can be calculated but no statistical analysis of throughput times is carried out. By looking at the period numbers on the route cards in each section, the Assembly Chargehands and Foremen can tell which jobs are behind schedule, and the extent of the delay. Each week, a Progress Clerk compiles a report on the number of potentiometers that are in lag; this does not show which orders are delayed. A copy of this "lag sheet" goes to the appropriate Production Engineer. When the factory was investigated, this was only carried out in the potentiometer sections but it was planned to extend the report to all final assemblies.

Sometimes, a Customer will telephone the factory to find out why an order has not been received and how long he will have to wait for it. He may contact the Sales Department or a Production Engineer directly. This may be the first indication to the latter that this order is behind schedule. The Sales Department will usually inform the Production Engineer concerned of customers' complaints but sometimes this will depend entirely on who the customer is.

Comparison:

A Progress Clerk is sometimes the first to see that a particular job, or jobs, will be behind schedule perhaps due to lack of parts in stores. This can be seen from the issue books and the Clerk will notify the Progress Supervisor of any significant hold-ups. As in a Sub-assembly Section, if a Chargehand notices a job that is delayed, he may do nothing if it is not important, try to correct the situation himself, or inform the Foreman if the instance is in his opinion serious enough. The Foreman must then decide whether anything should be done, and if so, what. The Foreman in turn may decide to inform the Production Engineer if the problem is one with which he feels unable to cope. The latter will be informed of most jobs that are behind schedule, either through the Foreman, the Progress Supervisor, the Sales Department or the Customer. He must decide how much attention each case merits taking into account the value of the order, the customer, and the extent and cause of the delay.

Decide Action:

If a job has been delayed through negligence or some unavoidable

factor, e.g. where the only Operator skilled enough to do that job is absent, the Chargehand will normally be able to decide on the appropriate corrective action. In most cases this will be without difficulty; the delayed job must be begun as soon as the Operator is available. The Chargehand will take the more intractable problems to the Foreman who in many cases will be able to decide what to do. It may even be necessary to stop work on one job in order that another be completed first.

If a job has been delayed through material shortage, the Progress Supervisor will be responsible for deciding what can be done to remedy the situation.

It is frequently the case that rectification work builds up in front of work not yet started, because the former have lower period numbers (otherwise they would not have been assembled first). If a job has been delayed in this queue to such an extent that to allow it to make its own way to the front would take longer than the customer is prepared to wait, then the Production Engineer must decide whether or not to give that job priority, and place it at the front of the queue.

Take Action:

Whatever action the Progress Supervisor decides to take with respect to material shortage, he will deal with it himself. He will contact the source of supply in an attempt to hasten delivery, or attempt to find an alternative supplier. The Chargehand and Foreman will take action in all those cases where they are competent, but only the Production Engineer may override the period batch system and place a job at the front of the queue regardless of its period number. The

Production Engineer would ensure that this was done through the Foreman.

4. Throughput time, Inspection

Measurement:

The period numbers on the route cards in the section reveal those items which are behind schedule. The Inspection Chargehand and Test Foreman can see this immediately. The Progress Clerks also have a record of throughput times but this is used only for reference.

Comparison:

The Inspection Chargehand may attempt to hasten the progress of a delayed job. An Operator may not know how to handle a new inspection schedule; a piece of apparatus may be faulty or require adjustment. If the duration of a delay, or its cause, is more serious, the Chargehand will inform the Test Foreman if the latter does not know of it himself. He may decide what, if anything, should be done, or he may decide to take the problem to his superior, the Assistant Quality Engineer, if he feels that he will be unable to cope with the situation himself.

If a Production Engineer has decided that a particular job be given priority and that job is in the Inspection Section, an Assembly Foreman (sometimes the Senior Foreman) will approach the Inspection Chargehand to find out how quickly that job will be ready. He may, if necessary ask the Inspection Chargehand to return the job to the assembly section with all haste, if the delay is not caused

by lack of materials or apparatus. This latter point may better be subsumed under control of final assembly throughput time but serves here to illustrate the high degree of interdependence between these factors.

Decide Action:

The Inspection Chargehand will attempt to solve all those problems which she thinks she is competent to deal with. It will also be possible to give a job to a more proficient Operator; or an Operator may require further instruction which the Chargehand can provide. The Test Foreman will be informed about and asked to deal with more serious delays, such as those arising from the complex technical problems which frequently arise.

If the solution to a particular problem is likely to affect the future operation of the Inspection Section, the Test Foreman will ask the advice of the Assistant Quality Engineer. For example, an inspection schedule may require alteration in some fundamental aspect.

Take Action:

Whoever decides what action should be taken to speed the passage of jobs that have been delayed in this section, the appropriate instructions will be relayed to the Inspection Chargehand for implementation. The Assistant Quality Engineer may transmit his orders in person, or through the Test Foreman.

5. Throughput time, Test

Measurement:

From the period numbers on the route cards, the Test Foreman and Test Chargehand can identify instantly those jobs which are lagging. As jobs enter the section, the Test Chargehand records each one in a book and cancels this entry when each job leaves. A separate page is kept for each day and it normally takes no more than three weeks for one page to be cancelled completely. This record is used only for reference; the Test Chargehand can tell from his book which jobs are in his section at any given time, and how long any particular job has taken to be tested. A page may not be cancelled until all the jobs listed on it have left the section, and consequently, jobs which have been held up are highlighted.

Comparison, Decide Action and Take Action operations are the same as those of the Inspection Section with the Test Chargehand here performing the same tasks as the Inspection Chargehand.

6. Quality of Products, Sub-Assembly

Measurement:

On completion, each batch of sub-assemblies is taken to the Inspection Section where an Inspection Operator checks each item against the pertinent inspection schedule. If the Operator believes that an item should be rejected, the Inspection Chargehand may be asked to confirm this. Some of the more experienced

Operators, however, are allowed to reject items on their own authority.

Comparison:

So it may be either the Inspection Chargehand or an Operator who decides whether an item be rejected or not. In a small number of problem cases the Chargehand may ask the Test Foreman, and sometimes also the Engineer I/C Control, for assistance.

Decide Action:

Items which pass this inspection are taken to the Stores for issue as component parts of final assemblies. Rejected items return to the Sub-assembly section. The Sub-assembly Chargehand, sometimes in conjunction with the Senior Foreman, decides whether the items be rectified or scrapped. The technical assistance of the Engineer I/C Control may also be enlisted at this stage. Jointly or severally, this group will decide how the items are to be rectified.

Take Action:

It is the responsibility of the Sub-assembly Chargehand to reissue items to be rectified to the Operator responsible.

7. Quality of Products, Final Assembly

Measurement:

Quality checks are made both during and after the final assembly stages. At certain points during the assembly items are taken to

the Inspection Section where an Inspection Operator checks the work carried out. As in the inspection of sub-assemblies, the Inspection Chargehand will frequently be asked to confirm any checks on suspect items. On completion, items go to the Final Test Section where Test Operators perform a variety of tests as listed on the test schedule for each type of item. The Test Chargehand also lists the number of each product tested and the number failed. The Test Foreman graphs these figures and a copy of this is put in the Assistant Quality Engineer's office.

Comparison:

The procedure relating to final assemblies in the Inspection Section is the same as that for sub-assemblies with the Inspection Chargehand or an experienced Operator making decisions to pass or reject items. In the Test Section, the Test Chargehand is the sole arbiter. Here, the Operator merely marks the test results on a card and passes this to the Chargehand who compares these with the requirements specified and decides whether or not to accept items. Either Chargehand may consult the Test Foreman about problems which they feel are outwith their competence. From the graph in his office, the Assistant Quality Engineer can see the failure rates of each product. If, in his opinion, this rate is too high for any product, he informs the Production Engineer concerned.

Decide Action:

If an item passes an inspection, it automatically returns to the assembly section to continue its build-up. On passing through

the Test Section, items automatically go to Despatch. Items which fail an inspection or test are separated from their batch and are returned to the appropriate assembly section for rectification. The Assembly Chargehand will normally decide what action should be taken to rectify any particular item, but the Assembly Foreman will be involved in problematical cases. They may both participate in determining the appropriate course of action, or the Foreman may arrive unilaterally at a decision. If the Assistant Quality Engineer has approached a Production Engineer with the information that the failure rates on his products are excessively high, the latter must decide on the appropriate action.

Take Action:

The Assembly Chargehand will return the items which must be rectified to the Operators who made them, giving them the agreed directions on the repair action to be taken. If the Production Engineer has been involved, and if he deems it necessary, he will examine the situation as thoroughly as possible and instruct his Assembly Foreman or Assembly Chargehand to take whatever action is necessary, such as ensuring that only experienced Operators are given difficult jobs, work benches and floors are kept clean, or checking any tools or equipment used for faults.

8. Quantity of Scrap, Sub-Assembly

Measurement:

The Quality Engineer (Mechanical) deals with all items that have been designated as scrap. The Sub-assembly sections each have

a "scrap-bin" into which these items are placed. The Quality Engineer empties these at the end of each month, sorts the items into product groups and maintains a record of the quantity scrapped in each group. Progress Clerks also record the percentage scrap in each batch but no overall statistics are calculated.

Comparison:

The scrapped items are then handed over to the Production Engineer and his Planning Engineer who examine it and decide if there are any parts which can be salvaged.

Decide Action:

The Production Engineer and the Planning Engineer also decide the manner in which parts will be salvaged. In some cases, the costs of rectifying damaged items may be greater than those of making new ones. The Planning Engineer puts the appropriate instructions onto a sheet which is made into a special route card headed "Scrap Recovery".

Take Action:

It is a Progress Clerk who types the route card and ensures that the items are issued to the appropriate sub-assembly section. Once there, it is up to the Sub-assembly Chargehand to give the job to an Operator.

9. Reject Concessions, Final Assembly

Measurement:

If an item fails a final test by a small margin it may be possible to allow it to pass by granting a concession, i.e. if the item is fit for its intended purpose then the deviation from requirements may be waived. The Company specifies certain "in-house" tolerances which are occasionally narrower than those which customers request. The item may be acceptable to the customer but not necessarily acceptable to the Company. The Assembly Chargehand, sometimes along with the Assembly Foreman, will note those items on which it may be possible to grant a concession.

Comparison:

They notify the Production Engineer who, with the assistance of the Planning Engineer, considers the case and decides whether to ask for a concession or have the item rectified. If the former course is adopted the Planning Engineer completes a request form which is sent to the Design and Sales Departments.

Decide Action:

The Design Department examines the consequences of deviations from specification. The Sales Department contacts the customer, to determine whether or not the item is acceptable, if they are not certain from past experience what that customer will decide. The Chief Quality Engineer, or his deputy, the Assistant Quality Engineer,

must also be signatory to the concession form. Recalling the existence of "in-house" quality requirements, the Chief Quality Engineer must be satisfied that the product itself, regardless of the customer's requirements, is fit to bear the Company's trademark. He thus has power to prevent the sale of an item even though the customer would accept it. The Company has a central quality assurance body to which the Quality Engineers are partially responsible.

Take Action:

If a concession is granted, the item is returned to the Assembly Chargehand who issues the item to an Operator for labelling from whence it goes to Despatch. If a concession is not granted, the product is returned to the assembly section to be rectified.

10. Methods of Work, All Assembly

Measurement:

By "methods of work" is meant the actual operations performed in assembling an item and the sequence in which they are carried out. Direct monitoring of these methods is achieved through dealing with problems as they arise during the assembly process. Indirectly, deviations in other factors such as quality or throughput time may indicate that work methods are ineffective. If an Operator experiences difficulty with a particular job, he or she will normally inform the Chargehand. The latter should then inform the Foreman who should in turn contact the appropriate Planning Engineer. Should the Operator find the Planning Engineer conveniently available, his advice may be asked without the Chargehand or Foreman knowing.

This is discouraged since in the event of another Operator meeting the same problem the Chargehand might not be able to deal with it in person and effort would be wasted in re-contacting the Planning Engineer.

Comparison:

The Chargehand or Foreman may be familiar with the problem and decide whether or not to do anything about it. If not, the Planning Engineer will examine the problem.

Decide Action:

The Chargehand or Foreman will be capable of solving some problems without assistance from the Planning Engineer. If an Operator has misunderstood some of the Planning Engineer's instructions, the Chargehand will be able to provide the necessary help. The Planning Engineer must solve those problems which the Chargehand or Foreman cannot. If an Operator is unable to carry out the instructions or use the "jigs and fixtures" provided, the Planning Engineer, having been responsible for both, must rectify the situation. He will take intractable problems, that have possible effects on future orders, to the attention of the Production Engineer who may on occasion involve the Production Manager.

Take Action:

The Chargehand is expected to deal with simple problems in this area where a word or two of instruction will suffice. With more difficult problems, the Foreman will be involved, perhaps putting a

more experienced Operator onto a difficult job. The Planning Engineer may have to write a new set of instructions or design new jigs and fixtures. Any new route cards required are dealt with by Progress Clerks in the normal manner. The Planning Engineer can personally provide instruction for Operators on the performance of certain operations or use of certain tools. He is usually capable of solving these problems but may on occasion act under instruction from the Production Engineer or Production Manager.

11. Methods of Work, Test and Inspection

Measurement:

As with the assembly sections, if an Operator has difficulty, he or she informs the Chargehand (Test or Inspection) who approaches the Test Foreman who informs either the Engineer I/C Control or the Quality Engineer (Mechanical).

Comparison:

The Chargehand or Foreman may be able to identify the nature of the problem. If not, the Engineer I/C Control or the Quality Engineer will determine the cause of the problem and decide if anything should be done.

Decide Action:

If the Chargehand or Foreman can solve the problem, the Engineers will not be involved. The latter may on occasion have to decide whether or not to alter an inspection or test schedule, or whether to

replace or repair test gear. Should radical alteration appear necessary, say in inspection or test schedules, the Assistant Quality Engineer, and sometimes the Chief Quality Engineer, may be involved.

Take Action:

The Test or Inspection Chargehand may be able to take necessary action alone; he or she may provide extra instruction for Operators. The Test Foreman may also be involved, perhaps in distributing difficult jobs to particular Operators, but normally he will instruct the Chargehand to do this. The Engineer I/C Control or the Quality Engineer may rewrite a test or inspection schedule. They may also check test gear if it is suspect. New test gear may have to be designed. The Engineers may personally instruct Operators in the use of schedules or test gear.

12. Operator Efficiency, Sub-Assembly

Measurement:

The Sub-assembly Chargehands have a responsibility for training their Operators and are able to distinguish the better ones by observation. Initially, an Operator will be taught to perform some of the easier types of work and will do this until the Chargehand considers that the Operator is capable of more difficult tasks. Thus the "training period" is protracted and the Chargehands formulate a detailed knowledge of the capabilities of their Operators.

Operators working normally are expected to earn a bonus. The Work Study Department calculate the standard times for each job in such a way that this is possible and when this Department calculates

the weekly bonuses, those Operators not earning bonus are identified and this provides some indication of efficiency.

Each route card indicates the Operator who performed the job, how long it took and what rectification work was necessary. These details are used only for reference while the job is on the shop floor and the only use made of them thereafter occurs when an Operator's work is suspect. Indication of this will generally come from the sources mentioned above and if the case is a serious one, the Production Engineer will have the Clerkess in the Quality Department extract a record of the Operator's recent work from the route cards. This procedure is comparatively rare.

Comparison:

There are no pass or fail rates stipulated against which an Operator's performance may be measured. Due to the nature of the work, faults develop in items no matter how skilled the Operator is. A certain proportion of items are expected to fail their first inspection and be rectified or scrapped. Operators working on difficult jobs may produce higher failure rates than those on easier tasks, and this is expected. The Sub-assembly Chargehands are expected to appraise the efficiency of their Operators and inform the Senior Foreman of any instances they feel merit attention. Usually, the Chargehand will not inform the Foreman without first attempting to ameliorate the situation in person. If such an attempt fails, the Chargehand informs the Foreman who may in turn take the case to the Production Engineer.

Decide Action:

If the Sub-assembly Chargehand is the first to detect an inefficient Operator, the initial action will be to determine the cause. The Operator may have personal problems, or may require more training or instruction. In either event, the Chargehand must decide how to alleviate the problem. In cases where the Senior Foreman has been informed, it will be his responsibility to decide what should be done and, usually, instruct the Chargehand accordingly. Where the Production Engineer is notified, and where he feels the case worthy of his attention, he will examine all the information he has available, from the Chargehand and Foreman, from the bonus records, and from the Operator's past production record. At this stage, attempts by the Chargehand and Foreman will normally have failed to improve the Operator's work, and the Production Engineer will consider moving the Operator to another section, or dismissal. If the latter course of action is preferred, the Personnel Department must be notified since it is only through that Department that an Operator can be fired.

Take Action:

The Sub-assembly Chargehand will speak to the Operator in an effort to persuade him or her to improve their work. The Chargehand may provide additional training or instruction. The Senior Foreman may wield his higher authority in a similar persuasive bid, or instruct the Chargehand to do this. They may decide not to give the Operator difficult work to perform where mistakes are more costly. The Production Engineer may either have the Senior Foreman move the

Operator to another section, or ask the Personnel Department to arrange for the Operator to be transferred to another part of the Company or dismissed.

13. Operator Efficiency, Final Assembly

Measurement:

The Assembly Chargehands are expected to monitor the efficiency of their Operators by observation, as with the Sub-assembly sections. The Work Study Department's record of bonus earnings are similarly available and the Clerkess in the Quality Department can compile the history of a Final Assembly Operator's performance from route cards.

The third time an item fails a test and is returned for rectification, the Test Chargehand must inform the Assembly Foreman concerned who signs the back of the card signifying that he is aware of the situation. It is also the responsibility of the Assembly Chargehand to inform the Foreman when any Operator's work is particularly bad.

Fortnightly product quality examinations are conducted, called "strip reports", where representatives from Production, Quality and Design Departments observe and criticise while an Operator dismantles one of his products which has failed a test. A report is written and circulated. The Production Engineer receives a copy. These reports are so infrequent as to render them inadequate as an indicator of individual Operator efficiency on a continuous basis. However, if the work of an Operator is suspect, one of his products may be selected for analysis.

Comparison:

The Assembly Chargehands will attempt to solve any problems they can. On deciding that an Operator's performance is particularly bad, the appropriate Assembly Foreman will be informed. The latter may also attempt to handle the matter, as in a Sub-assembly Section, or he may notify the Production Engineer. Information from bonus records and possibly a report on the Operator's recent work will be taken into consideration by the Production Engineer in deciding whether or not an Operator's work is sub-standard. As indicated in the above discussion on Sub-assembly Sections, this decision is highly subjective.

Decide Action:

It may be possible for the Assembly Chargehand to overcome any small problems which arise. The Assembly Foreman's advice will be taken in more serious cases. If a case has reached the Production Engineer, he will decide whether or not the problem can be solved within the Department. If not, he will ask the Personnel Department to arrange either for transfer of the Operator to another Department, or dismissal. Here, the decision actually lies with the Personnel Manager.

Take Action:

The type of action which the Assembly Chargehand may undertake is to offer the Operator further training or instruction. It is also possible for a Chargehand to ensure that an Operator is not given work which is beyond his capabilities to perform effectively. More serious cases the Assembly Foreman deals with, the action he would take

being similar to that of the Chargehand. The Production Engineer may speak to the Operator in an attempt to persuade him to improve. Alternatively, he may move the Operator to another section in the Department. If these attempts are unsuccessful, the Personnel Department arranges for the Operator to be transferred to another Department in the Company, or dismissed.

14. Operator Efficiency, Inspection

Measurement:

Since most Operators in this section, particularly the less experienced ones, must present any reject items to the Inspection Chargehand for confirmation, the latter is able to form a knowledge of each Operator's capabilities and, if the standard of an Operator's work falls, will soon discover this. The Chargehand also examines two complete jobs done by each girl every week. The result of this "overcheck" is kept in a folder with a page for each girl and this is passed to the Test Foreman at the end of each month. If an Operator makes a serious error, such as accepting items that are obviously faulty which could prove expensive if used in final assemblies, the Test Foreman completes a "fault slip" showing how this mistake arose; for example the Operator may not have had sufficient experience to deal with the job she was given, or the instructions on the schedule may not have been clearly understood.

As with the Assembly Sections, the Work Study Department provides information on Operator's bonus earnings and this is another guide to efficiency.

Comparison:

It is again difficult to stipulate the point at which an Operator may be deemed inefficient. If the Inspection Chargehand is the first to detect a lapse, she will attempt to solve the problem herself. Through the results of the "overchecks" and any "fault slips" which arise, the Test Foreman may decide whether anything should be done. If the case is serious, the Chargehand or Foreman will inform the Assistant Quality Engineer who examines the situation and formulates a view on whether the Operator's work is of the required standard.

Decide Action:

The Inspection Chargehand may decide to give an Operator further training or advice. The Test Foreman may proffer a similar solution or put the Operator on a different type of work where mistakes could be less costly. The Assistant Quality Engineer or the Chief Quality Engineer will decide serious cases. If they feel that the Operator should be removed, the Personnel Department will be asked to do this.

Take Action:

The Inspection Chargehand undertakes personally any Operator training required and is also responsible for ensuring that the Operator is given only particular types of work. The Test Foreman may reprimand the Operator, perhaps using his powers of persuasion to improve the work. The Assistant and Chief Quality Engineers may attempt to move the Operator to another section in the Department. If they request that the Operator be removed altogether, the Personnel Department will either arrange for the Operator to be transferred to

another department, or dismissed.

15. Operator Efficiency, Test

Measurement:

This operation is performed in the same manner as in the Inspection Section (Test Chargehand substituted for Inspection Chargehand) with one addition: items that are returned from customers as defective are subjected to investigation. The Quality Engineer (Electrical) performs this task and if it is discovered that an item was faulty when it left the factory, it is possible to identify the Operator who passed that item as fit for use by finding the original route card. This is, however, a rare occurrence.

Comparison; Decide Action; Take Action:

These are the same as for the Inspection Section with the Test Chargehand taking responsibilities similar to those of the Inspection Chargehand.

16. Task Allocation within a Section, All Assembly

Measurement:

The Chargehand is expected to know which Operators are good at which jobs and will usually give a difficult job to a more experienced Operator. The Foreman is also informed of the comparative abilities of his Operators through the channels mentioned in the description of control of Operator Efficiency.

Comparison:

The Chargehand or Foreman, or both, will consider those jobs which are either difficult, wanted quickly, or are for an important customer. They decide if any particular Operator should be chosen, or if a job should go to the first Operator available on reaching the front of the queue.

Decide Action:

If a Chargehand or Foreman decides that a job does require special attention, the most suitable Operator will be selected.

Take Action:

The Chargehand is responsible for giving particular jobs to designated Operators.

17. Task Allocation between Sections, All Assembly

Measurement:

The Senior Foreman compiles a graph of "waiting time" for each week from which he can see which sections, and which Operators, have too little work and which are overloaded. The other Assembly Foremen also report any excessive waiting time in their sections to the Senior Foreman as it arises.

Comparison:

The Senior Foreman decides whether or not the situation warrants a re-allocation of labour. If he considers the change to be radical,

he informs the senior Production Engineer who also examines the situation.

Decide Action:

The Senior Foreman or the Production Engineer, or both, decide what alterations to make to the distribution of Operators between sections.

Take Action:

The Senior Foreman sees that this is done.

18. Task Allocation within a Section, Test and Inspection

Measurement; Comparison; Decide Action; Take Action:

The procedure is the same as that for Assembly, substituting Test and Inspection Chargehands and Foreman for Assembly Chargehand and Foreman.

19. Task Allocation between Sections, Test and Inspection

Measurement:

The Test Foreman monitors the situation by observation to determine whether the balance of labour and work between the sections is satisfactory.

Comparison:

Any possible reallocation is discussed with the Assistant Quality

Engineer who may, depending on the extent of the proposals, take the problem to the Chief Quality Engineer at least for an approval of plans made if not for a decision.

Decide Action:

It is thus either the Assistant Quality Engineer or the Chief Quality Engineer, or both, to determine the distribution of Operators between these sections.

Take Action:

The Test Foreman has the responsibility of carrying out any redistribution.

20. Size of Work Force, All Sections

Measurement:

The Personnel Department maintains records of all employees; any additions to or reductions of the labour force must be processed by this Department.

Comparison:

The Personnel Department is informed of any changes that are to be made in the size of the labour force (see Planning description below). The Department must also be aware of any shortfall in labour requirements as it occurs.

Decide Action:

The manner of recruiting and dismissing employees is entirely

the responsibility of the Personnel Department, which is a "central service" within the Company, but outwith the control of the R.C.G. Manager.

Take Action:

Employees are dismissed only by the Personnel Manager. His Department initiates a recruitment campaign if more labour is required. Applicants are interviewed first by the Personnel Manager who determines the suitability of the candidate. The appropriate Foreman and Chargehand are asked to "interview" suitable candidates and present their opinions. The "interviewing" takes place as the prospective employee is shown round the shop floor. If the supervision agree on the suitability of the applicant, he or she is hired. If either is not satisfied, the Personnel Department is asked to provide another candidate.

21. Shop Floor Layout, All Sections

Measurement:

The Senior Foreman has an overall responsibility for assessing the existing layout.

Comparison:

Possible advantages from alterations to layout will be considered by the Senior Foreman. Benches may be better positioned, test gear may be moved.

Decide Action:

Small changes, the Senior Foreman will make on his own initiative.

With more radical changes, he will inform the Production Engineer if an assembly section is affected, or the Assistant Quality Engineer if a test or inspection section is involved. Often, an alteration in the layout of an assembly section will affect that of an adjacent test or inspection area. Mutual agreement is then reached between the parties concerned.

Take Action:

The Senior Foreman is responsible for supervising the required alterations.

Ferranti's routine control operations are summarised in the routine control grid shown in Figure 5.7 (A to C).

Stage 4 of the Analysis : The Planning Control Operations

Although the planning control grid has a format similar to the routine control grid, discussion of its content is better dealt with by taking each of the control operations in turn rather than by going through each control factor in turn. The interdependence of the control factors makes this manner of exposition more satisfactory. Once again the job titles of those who carry out the control operations, and which therefore appear on the planning control grid, have been underlined. (The planning control grid is shown in Figure 5.8 on page 408, below.)

Information Sources:

Planning is dependent upon the availability of information concerning the production (operating) system and its routine control.

Figure 5.7(a): Routine control grid for Ferranti's Rotating Components Group.

SECTION:	FINAL ASSEMBLY	SUB- ASSEMBLY	FINAL ASSEMBLY	INSPECTION	TEST	SUB-ASSEMBLY	SUB- ASSEMBLY
CONTROL FACTORS	Group	Throughput	Throughput	Throughput	Throughput	Quality of	Quantity of
CONTROL OPERATIONS	Output	Time	Time	Time	Time	Products	Scrap
MEASUREMENT	Administration Clerk; Cost Department.	Progress Clerks; Sub-Assembly Chargehand; Senior Foreman; Work Study Department.	Progress Clerks; Assembly Chargehand; Customer; Sales Department.	Progress Clerks; Inspection Chargehand; Test Foreman.	Test Chargehand; Test Foreman.	Inspection Operator; Inspection Chargehand.	Quality Engineer (Mechanical); Progress Clerks.
COMPARISON	Production Engineer.	Progress Clerks; Sub-Assembly Chargehand; Senior Foreman.	Progress Clerks; Assembly Chargehand; Foreman; Progress Supervisor; Production Engineer.	Inspection Chargehand; Test Foreman.	Test Chargehand; Test Foreman.	Inspection Operator; Inspection Chargehand; Test Foreman; Engineer I/C Control.	Planning Engineer; Production Engineer.
DECIDE ACTION	Production Engineer.	Sub-Assembly Chargehand; Senior Foreman; Progress Supervisor; Production Engineer.	Assembly Chargehand; Foreman; Progress Supervisor; Production Engineer.	Inspection Chargehand; Test Foreman; Assistant Quality Engineer.	Test Chargehand; Test Foreman; Assistant Quality Engineer.	Sub-Assembly Chargehand; Senior Foreman; Engineer I/C Control.	Planning Engineer; Production Engineer.
TAKE ACTION	Sub-Assembly Chargehand; Assembly Chargehand; Foreman; Progress Supervisor; Production Engineer.	Progress Clerks; Sub-Assembly Chargehand; Progress Supervisor.	Assembly Chargehand; Foreman; Progress Supervisor; Production Engineer.	Inspection Chargehand.	Test Chargehand.	Sub-Assembly Chargehand.	Progress Clerks; Sub-Assembly Chargehand.

Figure 5.7(b): Routine control grid for Ferranti's Rotating
Components Group, continued.

SECTION:	FINAL ASSEMBLY	FINAL ASSEMBLY	ALL ASSEMBLY	TEST AND INSPECTION	SUB- ASSEMBLY	FINAL ASSEMBLY	INSPECTION
CONTROL FACTORS	Product	Concessions	Methods of Work	Methods of Work	Operator Efficiency	Operator Efficiency	Operator Efficiency
CONTROL OPERATIONS	Quality	Procedure					
MEASUREMENT	Inspection Operator; Inspection Chargehand; Test Chargehand; Test Foreman.	Assembly Chargehand; Assembly Foreman.	Chargehand; Foreman; Planning Engineer.	Chargehand; Test Foreman; Engineer I/C Control; Quality Engineer (Mechanical).	Sub-Assembly Chargehand; Work Study Department; Clerkess (Quality).	Assembly Chargehand; Work Study Department; Clerkess (Quality); Assembly Foreman; Production Engineer; "Strip Reports".	Inspection Chargehand; Test Foreman; Work Study Department.
COMPARISON	Inspection Operator; Inspection Chargehand; Test Chargehand; Test Foreman; Assistant Quality Engineer.	Planning Engineer; Production Engineer.	Chargehand; Foreman; Planning Engineer.	Chargehand; Test Foreman; Engineer I/C Control; Quality Engineer (Mechanical).	Sub-Assembly Chargehand; Senior Foreman; Production Engineer.	Assembly Chargehand; Assembly Foreman; Production Engineer.	Inspection Chargehand; Test Foreman; Assistant Quality Engineer.
DECIDE	Assembly Chargehand; Assembly Foreman; Production Engineer.	Design Department; Assistant Quality Engineer; Chief Quality Engineer.	Chargehand; Foreman; Planning Engineer; Production Engineer; Production Manager.	Chargehand; Test Foreman; Engineer I/C Control; Quality Engineer (Mechanical); Assistant Quality Engineer; Chief Quality Engineer.	Sub-Assembly Chargehand; Senior Foreman; Production Engineer; Personnel Department.	Assembly Chargehand; Assembly Foreman; Production Engineer; Personnel Department.	Inspection Chargehand; Test Foreman; Assistant Quality Engineer; Chief Quality Engineer; Personnel Department.
ACTION	Assembly Chargehand; Assembly Foreman; Production Engineer.	Assembly Chargehand.	Chargehand; Foreman; Planning Engineer; Progress Clerks.	Chargehand; Test Foreman; Engineer I/C Control; Quality Engineer (Mechanical).	Sub-Assembly Chargehand; Senior Foreman; Production Engineer; Personnel Department.	Assembly Chargehand; Assembly Foreman; Production Engineer; Personnel Department.	Inspection Chargehand; Test Foreman; Assistant Quality Engineer; Chief Quality Engineer; Personnel Department.

Figure 5.7(c): Routine control grid for Ferranti's Rotating
Components Group, continued.

SECTION:	TEST	ALL ASSEMBLY		TEST AND INSPECTION		ALL SECTIONS	ALL SECTIONS
CONTROL FACTORS CONTROL OPERATIONS	Operator	TASK DISTRIBUTION		TASK DISTRIBUTION		Size of Work Force	Shop Floor Layout
	Efficiency	(a) Within a Section	(b) Between Sections	(a) Within a Section	(b) Between Sections		
MEASUREMENT	Test Chargehand; Test Foreman; Work Study Department; Quality Engineer (Electrical).	Chargehand; Foreman.	Senior Foreman.	Chargehand; Test Foreman.	Test Foreman.	Personnel Department.	Senior Foreman.
COMPARISON	Test Chargehand; Test Foreman; Assistant Quality Engineer.	Chargehand; Foreman.	Senior Foreman.	Chargehand; Test Foreman.	Assistant Quality Engineer; Chief Quality Engineer.	Personnel Department.	Senior Foreman.
DECIDE ACTION	Test Chargehand; Test Foreman; Assistant Quality Engineer; Chief Quality Engineer; Personnel Department.	Chargehand; Foreman.	Senior Foreman; Production Engineer.	Chargehand; Test Foreman.	Assistant Quality Engineer; Chief Quality Engineer.	Personnel Department.	Senior Foreman; Production Engineer; Assistant Quality Engineer.
TAKE ACTION	Test Chargehand; Test Foreman; Assistant Quality Engineer; Chief Quality Engineer; Personnel Dept.	Chargehand.	Senior Foreman.	Chargehand.	Test Foreman.	Personnel Department; Foreman; Chargehand.	Senior Foreman.

In discussing planning, therefore, the first consideration is the sources of this information. "Information sources" is not, therefore, a control operation, but the first row of the planning control grid is used for convenience to record these sources.

For most of the control factors there exist written records that can be used to provide historical information regarding the past fluctuations in a control factor (e.g. throughput times or scrap quantities). In a number of cases, however, this information is not necessarily in a usable format and may require further analysis or collation to render it useful for planning purposes. The information concerning throughput times is of this nature.

If performance of a particular control factor becomes unsatisfactory, indication that this has occurred may come from information regarding other control factors. Increasing throughput times may be due to assembly operator inefficiency, or to slow methods of work in the test or inspection sections. It may not always be necessary, therefore, to have detailed information about the behaviour of all the control factors in order to detect and attempt to rectify an error in any one control factor.

Set Standard:

Performance standards for the assembly sections are established by the General Manager and the Production Manager, the former having the ultimate responsibility for decisions made. These are joint decisions made after discussion that generally involves other departments. The output targets, for example, are related to the sales forecasts prepared by the Sales Department; product quality is partly dependent upon the designs which the Design Department produce.

So these other departments are consulted when necessary. Performance standards that apply specifically to the test and inspection sections are established by the General Manager and the Chief Quality Engineer. Layout of the shop floor is principally the responsibility of production section personnel but the Chief Quality Engineer is consulted if the layout is to be altered completely.

The process of setting standards establishes the overall performance patterns expected of the production system, the performance standards that the routine control operations attempt to maintain. The standards of performance that can be set are constrained to some extent by the primary decisions. The quality of products that are to be produced is determined in this case by the primary decision to manufacture rotating components that will be used extensively in airborne navigation systems; the Group is committed to manufacturing products to the highest standards of quality possible. Similarly, the amount of resources that are to be used to make these products puts certain constraints upon the level of output that is possible. The factory could increase output (and costs) by increasing overtime and weekend working, but there will come a point where the only way to go on increasing output will be to increase the amount of resources used in production, i.e. to build a larger factory or build an extension onto the existing factory, to house more machinery and operators. Primary decision making thus constrains the standards that can be set at the planning level of control.

At the planning level of control it is impossible to regard control factors in isolation. They are generally closely interrelated in such a way that any change in one control factor will affect several others at the same time. The size of the work force must

remain stable if stable output is to be achieved; operators must be capable of working to the required quality standards; operators must be able to work to a degree of efficiency such that throughput times are consistent with delivery dates. These are just some examples of the degree of interrelationship between control factors. These interrelationships can become extremely complex and performance standards should ideally be kept under constant review.

Measurement:

For the assembly sections as a whole, the Production Engineer and the Production Manager are responsible for monitoring performance. With regard to methods of work, the Planning Engineer who draws up the Operators' assembly instructions is responsible for monitoring the effectiveness of the methods used. With regard to output and throughput times, the General Manager also has a specific measurement responsibility due to the importance attached to these factors. Output graphs are in fact posted in an Administration area outside the General Manager's office. The Sales Manager informs him of any important orders that are significantly overdue.

In the Test and Inspection Sections, the Assistant and Chief Quality Engineers perform this measurement operation. With regard to methods of work, the Quality Engineer (Mechanical) and the Engineer I/C Control, who draw up inspection and test schedules, also have a measurement responsibility.

The measurement operation involves monitoring the production system's actual performance and noting the extent to which the system is able to adhere to the performance standards.

Comparison:

This operation is performed for the assembly sections by the Production Engineer and the Production Manager; the Planning Engineer is again responsible for methods of work, and the General Manager has a particular responsibility for output and throughput times. In the Test and Inspection sections, comparison is carried out by the Assistant and Chief Quality Engineers, with the assistance of the Quality Engineer (Mechanical) and the Engineer I/C Control where methods of work are concerned.

The comparison operation is carried out in order to identify any problems in the operation or control of the production system that might warrant a change in work method. Beneficial developments that should perhaps be encouraged may also be identified.

Decide Action:

This operation determines any adjustments that have to be made to either the production system or its routine control. The members of the organisation who set the performance standards for the production system have been mentioned above; in taking the decision to change these standards, or to change the routine control methods, additional members of the organisation are invariably consulted.

The General Manager and Production Manager carry out this operation for the assembly sections; the General Manager and the Chief Quality Engineer carry it out for the Test and Inspection sections. The Chief Quality Engineer is consulted about all matters concerning plant layout since his sections are liable to be affected, and he is also consulted in all matters related to

product quality. The appropriate Production Engineer and the Assistant Quality Engineer are consulted on matters concerning methods of work in their respective sections.

Examples of the types of decision that may be taken at this stage are:

- rearranging the shop floor layout to decrease throughput times;
- changing from the "period batch" system to some other means of progressing jobs through the factory;
- altering the ratio of inspection to assembly operators in order to increase production;
- taking the responsibility for issuing work to operators away from the chargehands and allowing the operators to do this themselves.

It is the intention of this short list to be illustrative and not comprehensive.

Take Action:

The Production Engineer in each assembly section is responsible for ensuring that decisions taken are put into effect in his section. The Planning Engineer deals with alterations to methods of work, and if any changes are to be made to the size or composition of the workforce, this will be the responsibility of the Personnel Department.

For the Test and Inspection sections the Assistant Quality Engineer ensures that any planning decisions are implemented; the Quality Engineer and Engineer I/C Control are responsible for alterations to methods of work.

Figure 5.8(a): Planning control grid for Ferranti's Rotating Components Group.

SECTIONS:	FINAL ASSEMBLY ONLY					ALL TEST AND INSPECTION			
CONTROL FACTORS	Group Output	Throughput Time	Product Quality	Conceded Items	Operator Efficiency	Methods of Work	Task Distribution Within Sections	Task Distribution Between Sections	Size of Work Force
CONTROL OPERATIONS									
INFORMATION SOURCES	Administration Clerk; Cost Department.	Progress Section's Issue Books; Sales Department; Customer.	Test Records; Test Chargehand; Foreman's graph.	Concession Forms.	Work Study Department; Test Records; "Strip Reports".	Test and Inspection Schedules.	Chargehand; Foreman; Route Cards.	Foreman; Assistant Quality Engineer; Route Cards.	Personnel Department.
SET STANDARD	General Manager and Production Manager.		Chief Quality Engineer.	(Sales Manager and Chief Engineer.)		General Manager and Chief Quality Engineer.			
MEASUREMENT	Production Engineer; Production Manager; General Manager.			Production Engineer and Production Manager.		Quality Engineer (Mechanical); Engineer I/C Control; Assistant and Chief Quality Engineers	Assistant Quality Engineer and Chief Quality Engineer.		
COMPARISON	Production Engineer; Production Manager; General Manager.			Production Engineer and Production Manager.		Quality Engineer (Mechanical); Engineer I/C Control; Assistant and Chief Quality Engineers.	Assistant Quality Engineer and Chief Quality Engineer.		
DECIDE ACTION	General Manager and Production Manager.		Chief Quality Engineer.			Assistant and Chief Quality Engineers; General Manager.	Chief Quality Engineer and General Manager.		
TAKE ACTION			Production Engineer	Assistant Quality Engineer.		Quality Engineer (Mechanical); Engineer I/C Control.	Assistant Quality Engineer		Personnel Department.

Figure 5.8(b): Planning control grid for Ferranti's Rotating
Components Group, continued.



SECTION:	ALL ASSEMBLY					SUB-ASSEMBLY ONLY			
CONTROL FACTORS CONTROL OPERATIONS	Methods of Work	Task Distribution Within Sections	Task Distribution Between Sections	Size of Work Force	Plant Layout	Throughput Time	Product Quality	Scrap Quantity	Operator Efficiency
INFORMATION SOURCES	Master Route Cards.	Chargehands; Foremen; Route Cards.	Production Engineer; Foremen and "Waiting Time" Graph; Route Cards.	Personnel Department.	Senior Foreman.	Progress Section's Issue Books.	Progress Section's Issue Books.	Progress Section's Issue Books; Quality Engineer (Mechanical)'s Records.	Work Study Department; Test Records.
SET STANDARD	General Manager and Production Manager (Sales Manager and Chief Quality Engineer.)					General Manager and Production Manager (Sales Manager and Chief Quality Engineer)			
MEASUREMENT	Planning Engineer; Production Engineer; Production Manager.		Production Manager and Production Engineer.		Chief Quality Engineer.		Production Manager and Production Engineer		
COMPARISON	Planning Engineer; Production Engineer; Production Manager.		Production Manager and Production Engineer.				Production Manager and Production Engineer		
DECIDE ACTION	Production Engineer; Production Manager; General Manager.		General Manager and Production Manager.		Production Manager; Chief Quality Engineer; General Manager.		General Manager and Production Manager		
TAKE ACTION	Planning Engineer.	Production Engineer.		Personnel Department.	Production Engineer.		Production Engineer		

Figure 5.8(c): Planning control grid for Ferranti's Rotating Components Group, continued.

SECTIONS:	INSPECTION ONLY		TEST ONLY	
CONTROL FACTORS	Throughput	Operator	Throughput	Operator
CONTROL OPERATIONS	Time	Efficiency	Time	Efficiency
INFORMATION SOURCES	Progress Section's Issue Books.	Work Study Department; Overcheck Records; Fault Slips.	Progress Section's Issue Books; Chargehand's Register.	Work Study Department; Overcheck Records; Fault Slips; Defect Investigation Reports.
SET STANDARD	General Manager and Chief Quality Engineer.			
MEASUREMENT	Assistant Quality Engineer and Chief Quality Engineer.			
COMPARISON	Assistant Quality Engineer and Chief Quality Engineer			
DECIDE ACTION	Chief Quality Engineer and General Manager.			
TAKE ACTION	Assistant Quality Engineer			

In general, these are the personnel that are responsible for acting upon the planning decisions that affect their respective areas of responsibility.

Stage 5 of the Analysis : Primary Decision Making

Products

Measurement:

The discovery and recommendation of potential additions to the Group's product line is the responsibility of the Design and Sales Departments. The Sales Manager and Chief Engineer should therefore keep themselves informed of any such developments. The same is true for the possibility of discontinuing certain products.

Comparison:

The suitability of any potential alterations to the product line are assessed initially by the Sales Manager and the Chief Engineer. At this stage any significant developments will be brought to the attention of the Production Manager and the General Manager. The latter will in turn examine the proposals from their point of view and the Chief Quality Engineer will usually be consulted because it is his task to ensure that any new product conforms to the company's quality standards.

Decide Action:

The Rotating Components Group (RCG) is part of Ferranti's Inertial Systems Department (ISD) and the General Manager (RCG) is directly responsible to the General Manager of that Department.

Any product additions or deletions within existing groupings can be made on the authority of the General Manager (RCG), in consultation with the Sales Manager, Chief Engineer, Production Manager and Chief Quality Engineer. If it was considered necessary or desirable to stop producing an entire group of components or to start producing a completely new type of component, the General Manager (ISD) would also be involved in making the decision.

Take Action:

The implementation of decisions taken at this level, as far as the production system is concerned, is the responsibility of the Chief Quality Engineer and the Production Manager. The staff of the various sections will be informed of the changes; operators may require additional training; Operators, Chargehands and Foremen may be re-allocated to other sections to cope with altered work loads; the floor layout may have to be changed.

Resources

Measurement:

The General Manager receives a detailed monthly report on the financial status of the Group from the Accountants in the Cost Department.

Comparison:

It is the responsibility of the General Manager to determine, partly on the evidence of these reports, how well the Group is performing and how trends may develop in the future.

Decide Action:

The General Manager (RCG) has authority to expand his production facilities and output at his own discretion provided this is achieved through the Group's profits. If it appeared, however, that another factory should be built to contain increasing production, the General Manager (ISD) would be consulted. The respective opinions and suggestions of the Chief Engineer, Sales Manager, Chief Quality Engineer and Production Manager would also be taken into consideration.

Examples of the types of decision taken here are:

- the purchase of new test gear, work benches and other equipment;
- building an extension to the existing factory or building a new factory;
- purchasing a computer (or the services of a computer bureau) to handle the production progressing procedures.

Take Action:

The implementation of these decisions is again the responsibility of the Chief Quality Engineer and the Production Manager. They must ensure that the introduction, or removal of resources used in the production system is carried out effectively.

The Primary Decision Making Grid is shown in Figure 5.9. It is clear that the decisions taken at the planning and primary decision levels will be dependent upon a good deal more information than has been discussed here. Information from other operating

PRIMARY DECISION FACTORS →	PRODUCTS	RESOURCES
MEASUREMENT	Sales Manager; Chief Engineer.	Cost Department.
COMPARISON	Sales Manager; Chief Engineer; Production Manager; Chief Quality Engineer; General Manager (RCG).	General Manager (RCG).
DECIDE ACTION	General Manager (RCG); General Manager (ISD); Sales Manager; Chief Engineer; Production Manager; Chief Quality Engineer.	General Manager (RCG); General Manager (ISD); Sales Manager; Chief Engineer; Production Manager; Chief Quality Engineer.
TAKE ACTION	Production Manager; Chief Quality Engineer.	Production Manager; Chief Quality Engineer.

(RCG) = Rotating Components Group

(ISD) = Inertial Systems Department

Figure 5.9: Primary decision making grid for Ferranti's
Rotating Components Group.

systems within the Group and from the company's environment as a whole would have to be taken into account in addition to information concerning the control factors in the production system. But for reasons concerning the time required to analyse these procedures and their accessibility for study, the organisational analysis in these case studies does not proceed beyond this point. Discussion of the results of these case studies is postponed until they have been described.

This will facilitate discussion of the similar results and conclusions derived from these case studies.

2. CASE STUDY 2 : WILKIE AND PAUL, PLASTICS PRODUCTION DEPARTMENT.

Wilkie and Paul, Tin Boxes and Plastics

The second company approached in connection with this research was Wilkie and Paul, Ltd., which now has two factories at Slateford in Edinburgh, which manufacture plastic and tin containers respectively. The second case study reported here thus concerns the manufacture of plastic containers and the third, presented in Appendix IV, deals with the manufacture of tin containers.

Wilkie and Paul was established in 1861 in Leith, as brass founders and tinplate workers. The original factory made oil lamps for carriages, chandeliers and a variety of other brass, copper and tin artefacts characteristic of that period. As sales increased, the company twice moved to larger premises in Edinburgh. The market for tin containers was considered by the company to be an expanding one. So, in conjunction with one John Rhodes of Wakefield, the first plant in the world to mechanise the process of making tin containers was designed. The company moved to its present site in Edinburgh in 1920, the machinery was improved, and the market for the company's products in England expanded. In 1961 the company invested in plant for the manufacture of thermo-formed (i.e. heat formed) plastic trays and other types of plastic container, and this accounted in 1973 for approximately 60 per cent of the company's turnover. Also in 1961 Wilkie and Paul became a subsidiary of Scotcros Ltd., but almost full autonomy has been retained.

While these two case studies took place, a new factory was nearing completion in Slateford, not far from the existing site.

The tin container manufacturing machinery was moved to this new factory in April 1974 leaving the plastics side with more space in the original factory.

Products and Markets

Wilkie and Paul employs approximately 200 people in the manufacture of a number of types of thermo-formed plastic trays and containers which are used for packaging foodstuffs. The factory also produces all the plastic sheeting that it requires, turning to outside suppliers only in emergencies.

The plastic trays are generally called "inserts" and are used in the packaging of biscuits and confectionery. Containers, or "tubs" are produced for margarine, butter, yoghurt and similar products. Inserts and tubs are produced by vacuum forming and pressure forming processes respectively. The factory also has two machines for printing the sides and lids of tubs, but these machines are not in regular use.

Repeat standard orders form the bulk of the factory's output. Once machinery is operating on a given order, it is frequently allowed to continue producing after the order quantity has been reached as this is often more expedient than cleaning and resetting the machinery immediately. The excess output is stored against future orders. It is not standard procedure, however, to manufacture for stock. The company also has the expertise and facilities for designing and manufacturing novel or non-standard lines.

Manufacturing Facilities

The organisation chart for Wilkie and Paul's plastics production department is shown in Figure 5.11. The organisation chart shown in Figure 5.10 shows the departments common to both tin and plastic containers production. The plant layout illustrated in Figure 5.12 is that of the older factory, before the tin box production was moved to the new site. (A layout plan of the new factory had not been finalised by the time these case studies were completed.)

The production of plastic containers at Wilkie and Paul is divided into the six sections listed in Figure 5.13 which also shows the composition of each of these sections, and the equipment that each uses.

The manning arrangements for the extrusion, mixing and grinding sections differ from those of the other sections. These three sections operate on a "continental shift system". There are four Supervisors and four groups of Operators. Any one Supervisor and any one group of Operators works for five days, working 12 hour shifts with 12 hours in between. At the end of this five day stretch they take five free days before returning. So at any one time there will be:

- one group operating a twelve hour shift;
- one group waiting to come onto the next twelve hour shift;
- two groups each taking a five day break.

The Supervisors are encouraged to work split shifts, thus supervising two different groups of Operators for six hours each, in order to prevent them from regarding any one group of Operators as "their" particular group.

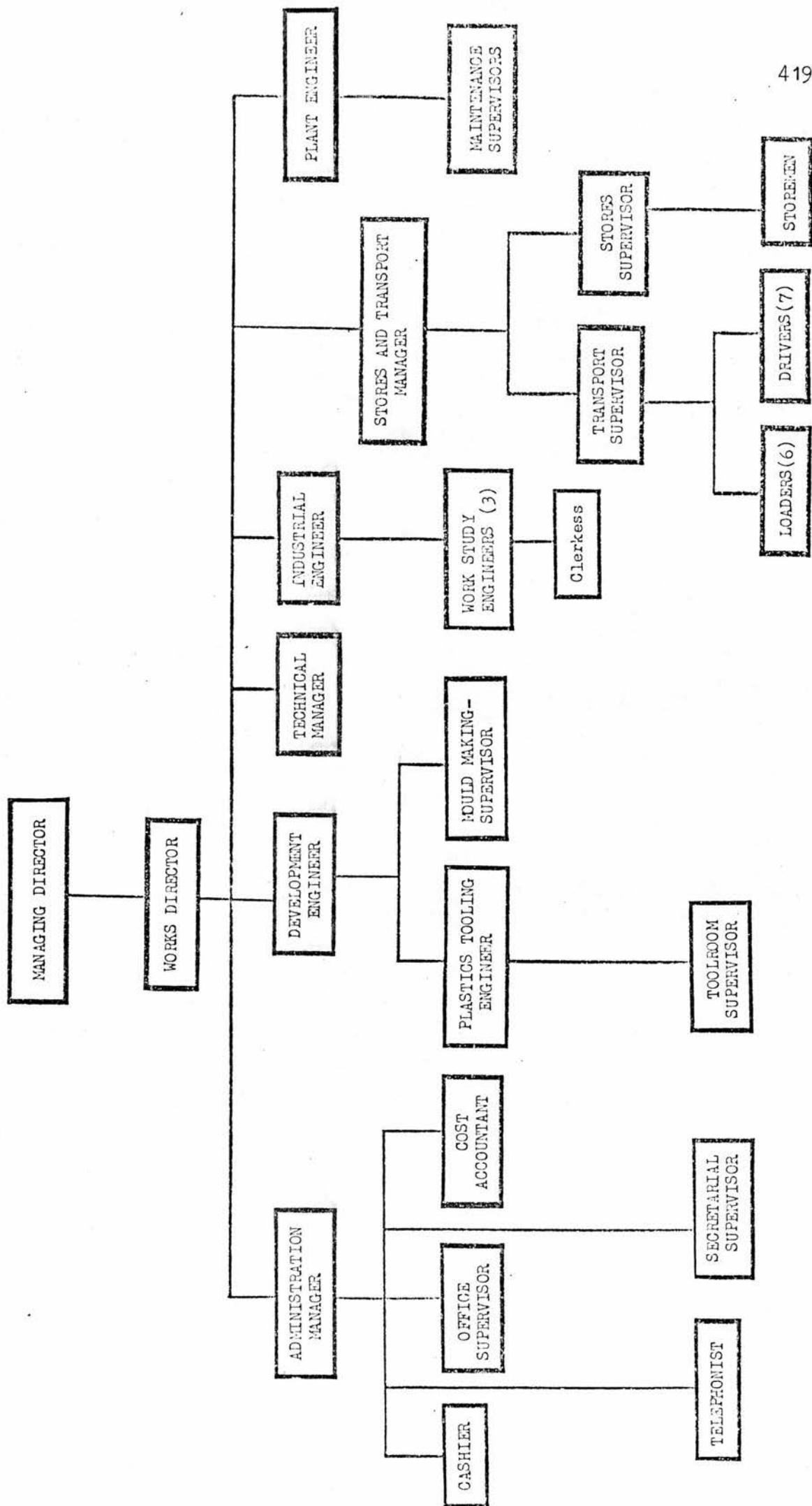


Figure 5.10: Organisation chart of Wilkie and Paul Ltd. continued overleaf

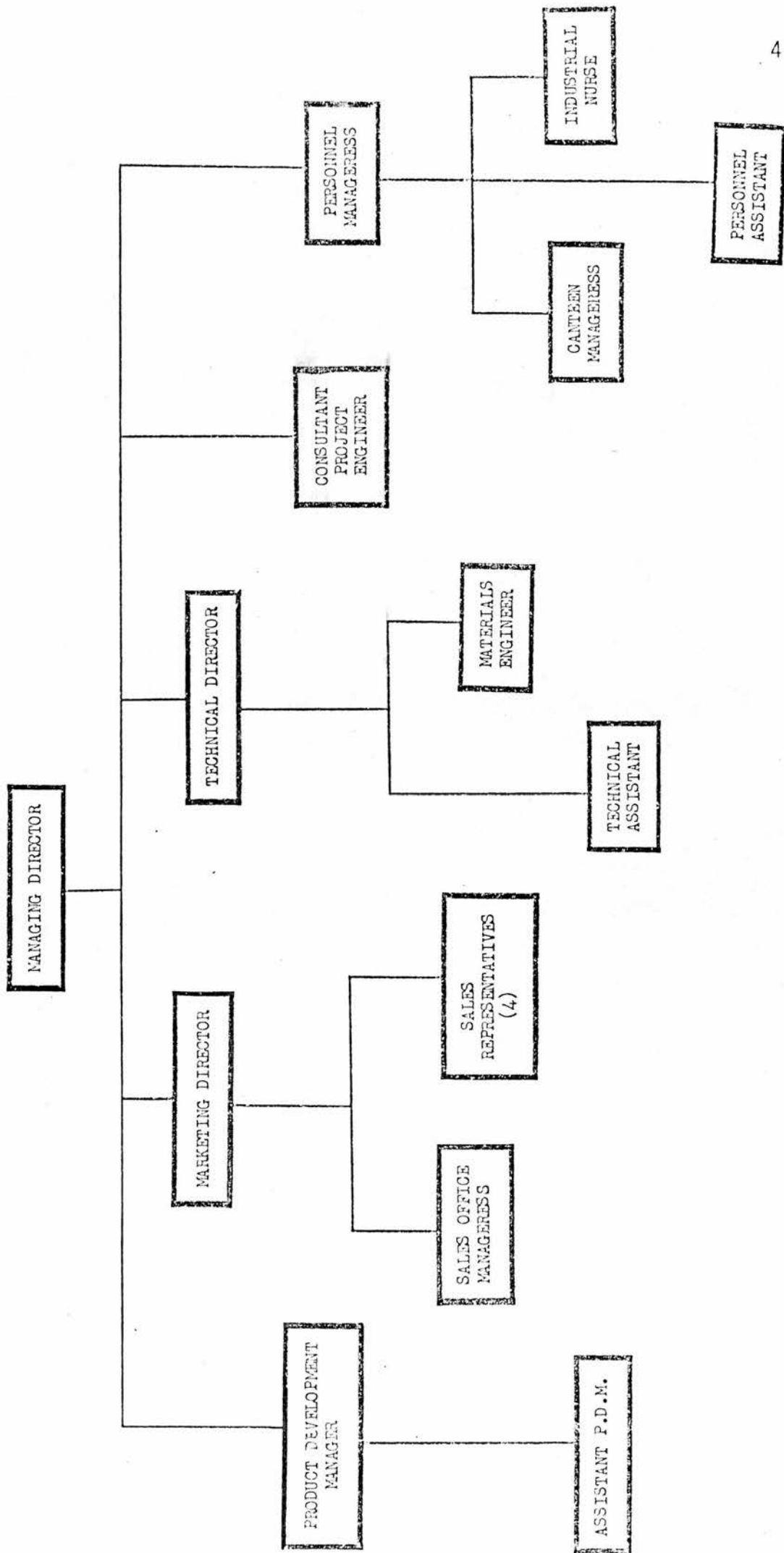


Figure 5.10 continued: Organisation chart of Wilkie and Paul Ltd.

Figure 5.11:
Wilkie & Paul Plastics Production Sections Organisation Chart.

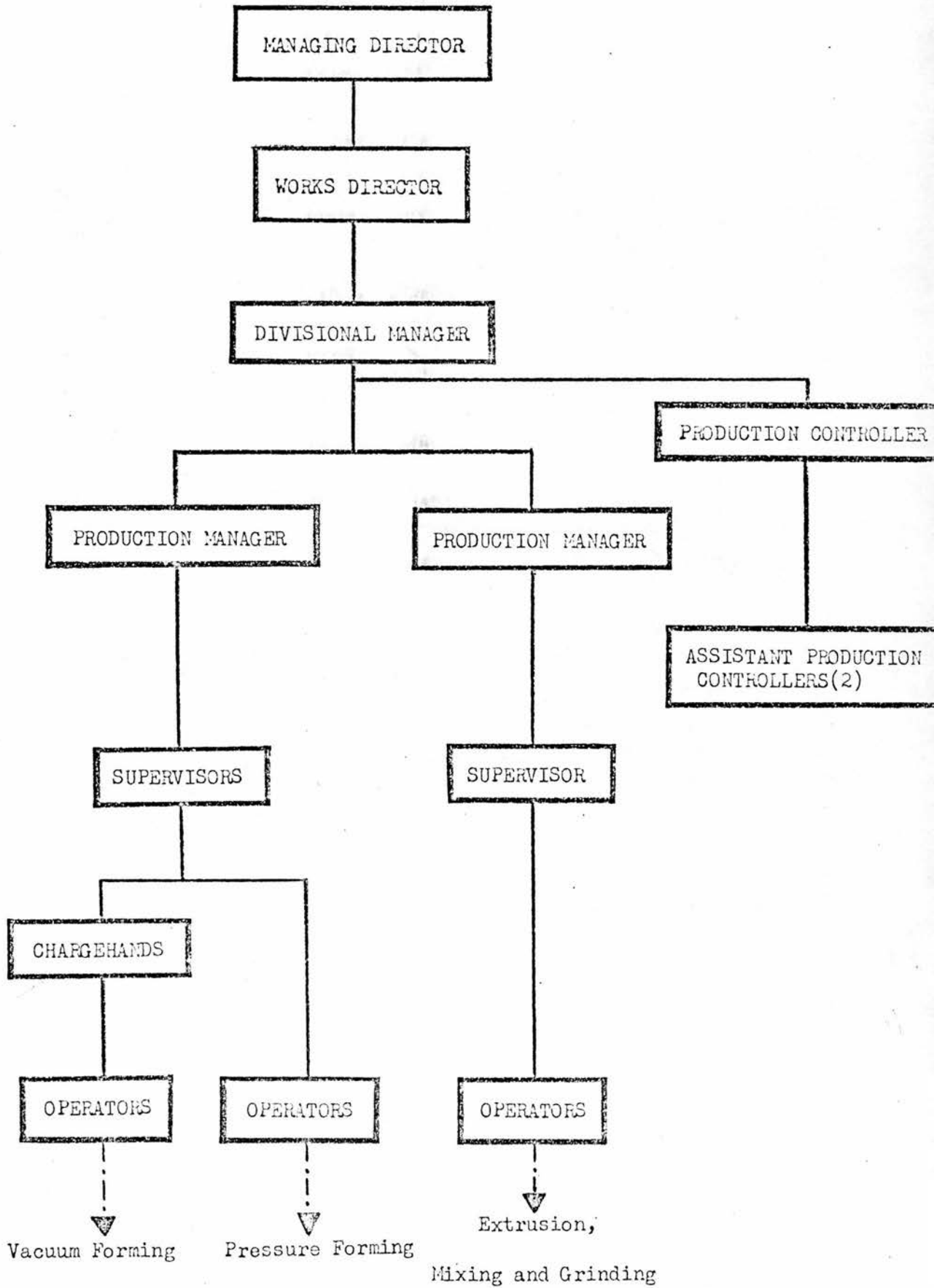
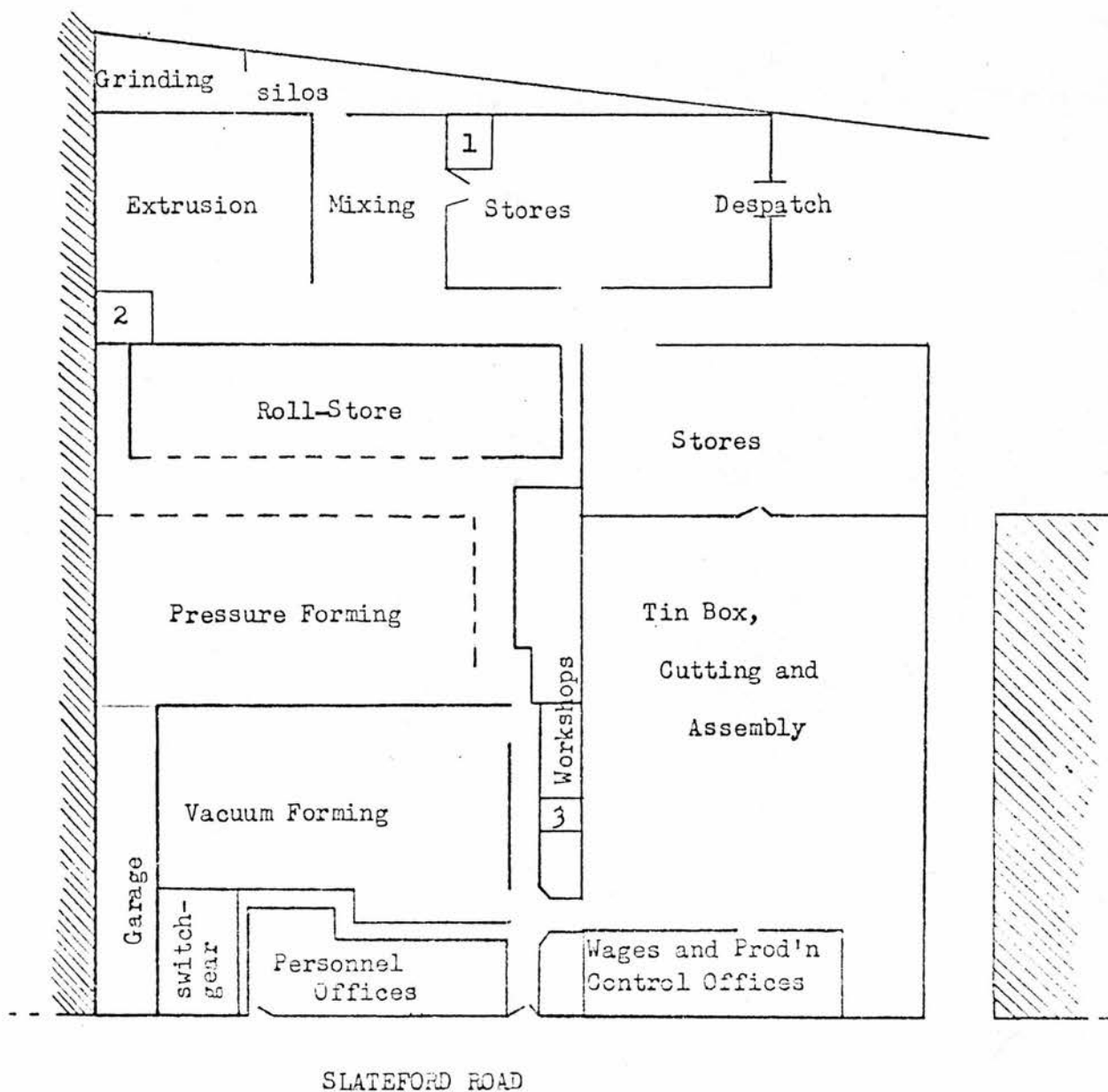


Figure 5.12: Wilkie and Paul Plant Layout, January 1974.

Scale: 50ft to 1 inch.



1: Office of Stores Supervisor.

2: Office of Production Manager, Extrusion.

3: Office of Production Manager, Vacuum and Pressure Forming.

Figure 5.13: Wilkie & Paul: Plastics Production Sections.

Section	Operators (Day Shift)	Equipment
Extrusion	1 Calander Operator 1 Extruder Operator	1 Calanderette, and 3 Diamat Extruders
Mixing	1 Mixer Operator	1 Mixing Machine
Grinding	1/2 Grinder Operators	2 Grinding Machines
Pressure Forming	3 Operators (female) 2 Setters	2 Pressure Forming Machines
Vacuum Forming	45 Operators (female) 2 Setters 2 Service Labourers	8 Vacuum Forming Machines 16 Cutting Tables
Others (Printing and Shredding)	as required	1 Body Printing Machine 1 Lid Printing Machine 1 Shredder

These sections operate for 24 hours per day over a seven day week. The extrusion machines are in constant operation (apart from maintenance and cleaning breaks) and the mixer and grinding machines are operated as required. The mixing machine produces mixes faster than the extruders can use it; the grinding machines are dependent for their workload on the quantities of scrap or "shred" returning from the forming sections. The Operators in the extrusion, mixing and grinding sections are constantly employed on operating the machinery, cleaning, setting and maintaining it, and keeping the section area clean and tidy.

The vacuum and pressure forming sections operate in a somewhat different manner from the extrusion, mixing and grinding sections. Here there are two female Supervisors who work together over both of these sections, without specific areas of responsibility. But there are two female Chargehands who work only in the vacuum forming section; one has responsibility for two vacuum forming machines and four cutting tables, the other has responsibility for six machines and twelve tables. These sections work a 5 day week, the day shift operating from 8.00 a.m. to 5.00 p.m. A Saturday morning shift, 8.00 a.m. to 12.00 p.m., is occasionally worked if necessary (but the total number of such shifts that can be operated in any one year is limited by statute governing the use of female labour). Day shift Operators wishing to work overtime may remain until 7.00 p.m. on any weekday. A separate evening or "twilight" shift operates from 6.00 p.m. to 10.00 p.m. and consists of about 30 female Operators most of whom are married. A night shift, 8.00 p.m. to 8.00 a.m., is worked by eight Operators and one Setter, all male. Once the female Operators leave, the

men operate only the forming machines; they do no cutting or packing but leave this for the female Operators to complete the following morning. Although these sections come under a different Production Manager, the Supervisor in the extrusion, mixing and grinding sections has charge of the forming sections during the night shift.

The pressure forming and printing machines are not in constant use. These activities provide a marginal contribution to the work and output of the factory. The shredding machine is used to render scrap from the pressure forming machines suitable for regrinding. Scrap from the vacuum forming machines does not require this treatment. Once put in motion by a Setter, the shredding machine can be left unattended for some considerable time. Pressure forming machines are also put in motion by the Setters, but once they have ensured that the machines are running satisfactorily, female Operators take over. The latter are moved to and from the vacuum forming section as required.

The numbers of female Operators in the forming sections (listed in Figure 5.13) are approximate. To operate the pressure forming and printing machines requires up to ten Operators, but it is not often that all these machines are working simultaneously. Another reason for these numbers being approximate is that the nature of the work has led to a rather high rate of labour turnover in these sections (over 180 per cent per annum), and the number of Operators on the factory floor can vary significantly from month to month.

Any maintenance or repairs that cannot be carried out by the Setters are referred to a separate maintenance section, under the

Plant Engineer. These mechanics and electricians deal with the tin container production machinery as well.

Stage 1 of the Analysis : The Tasks Involved in the Manufacturing Process.

Incoming orders are received by the Sales Office Manageress, who records these in the Sales Office file, giving order copies to the Production Controller (Plastics). Repeat orders comprise the larger part of output and a small file is kept that lists the standard material requirements of each product (allowing for normal wastage). Knowing the material requirements and the current scheduled work load, the Production Controller is able to calculate a delivery date for each order and the Sales Office can then tell the customer when that order will be delivered.

The Production Controller works from a large "load board" which lists each machine in the extreme left hand column and which has a time scale marked off in weeks across the top. The board is used to schedule up to four months production in advance. To programme a particular order, the Production Controller first calculates how long it will take to make the required material. He can then schedule this on one of the extrusion machines. He can then schedule the completion of the order on one or more of the forming machines, at any time after the scheduled completion date for the material, depending on the orders that have already been scheduled. Weekly schedules are prepared, based on the load board, for all the machines in the plastics production department. These schedules simply state the work that each machine will carry out during that week, and they are distributed to the Production

Managers and the appropriate Supervisors at the start of each week. Deviations from these schedules are inevitable and the Production Controller has to adjust his load board accordingly. If a particular order is likely to be significantly delayed, the Sales Office can be informed almost immediately in case the customer has to be contacted.

The weekly schedules distributed to the Production Managers and the Supervisors gives only a brief account of the programmed work load for each machine. Accompanying these schedules, therefore, are "order slips" which indicate the product to be made, the customer, the order quantity, and various specifications concerning the material to be used, the forming cycle time and packing instructions.

Figure 5.14 illustrates the stages of the manufacture of plastic inserts and tubs. The production of rolls of plastic sheet, the basic material for the forming stages, is essentially the first main part of the overall process. Plastic is actually a mixture of various chemicals, but 90 per cent of this mixture is basic polymer. The polymer is purchased from external suppliers and is stored in silos at the rear of the factory. (See Figure 5.12.) In order to give the basic polymer the characteristics and colour required for the stages to follow, various other chemicals (referred to as "lubricants and stabilisers") and pigment have to be added to it. The company chemists have compiled standard "mix cards" which indicate the exact amount of each ingredient that must go into each type of mix. Working from the weekly schedule, therefore, the Mixer Operator pumps the required amount of polymer for each mix into the mixing machine from the silos. The other chemicals and pigments are dropped in

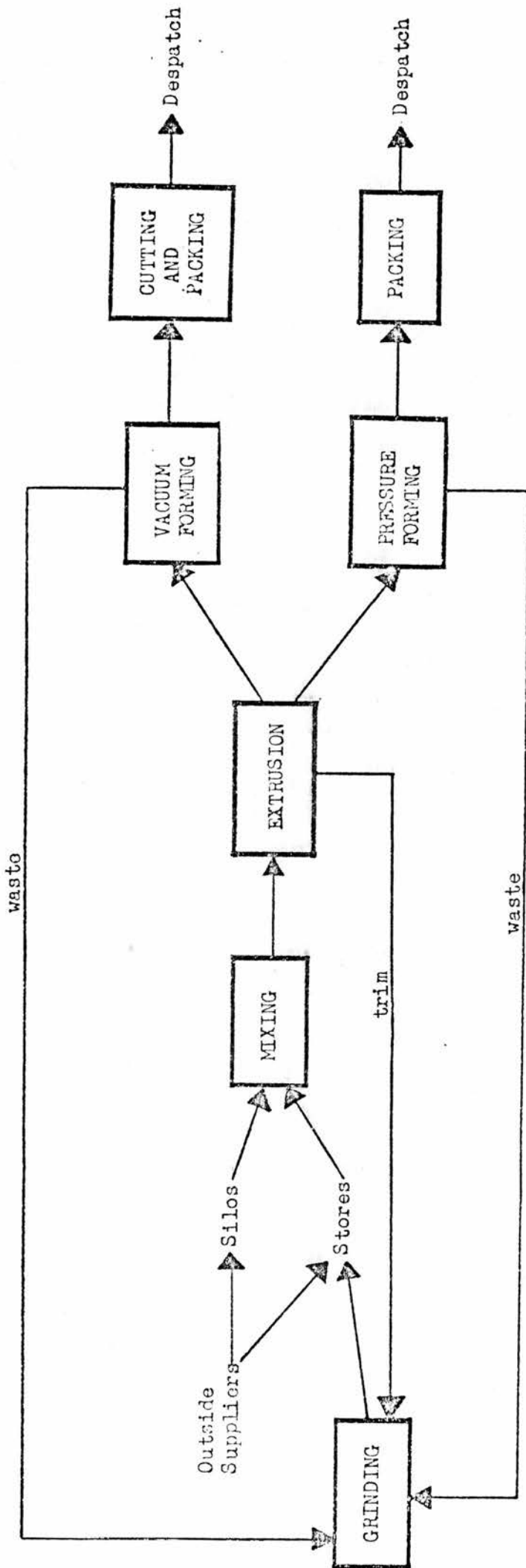


Figure 5.14: Wilkie and Paul, Plastics Production Process.

manually. The Production Controller sometimes schedules standard mixes for stock when there is no other work to be done. The completed mixes are pumped in to large vats("durabins") which are taken when full by fork-lift truck to the storage area.

The Mixer Operator is also responsible for the routine maintenance and cleaning of his equipment and the surrounding area. He completes a "daily record sheet" indicating the number of batches mixed on his shift. This is sent to the Work Study Department where it is used in the wages bonus calculations before being passed on to the production control section.

When required for extrusion, the vats of mixes are transported to the appropriate extrusion machine and the mix is pumped into a hopper above the machine. (Figures 5.15 and 5.16 show sketches provided by the company of the two types of extrusion machine that they use.) The calanderette extruder is much larger than the older diamat extruders and the plastic sheet that the calanderette produces is of a much higher quality. The mix is fed from the machine's hopper into a heated barrel along which it is moved by a motor-driven screw. The heat melts the mixture which is forced out, i.e. extruded, through a narrow slit in the heated die to produce a thin flat plastic sheet about three feet wide. On the calanderette, the sheet is fed between two driven rollers causing a small bank or "melt" of the material to build up at that point. This has the desirable effect of pushing contaminating particles to the edges of the material which are trimmed off in inch wide strips and reground for future use. This trimming also ensures that the material has a consistent, standard width. On the diamat extruders, the plastic sheet on coming out of the die is

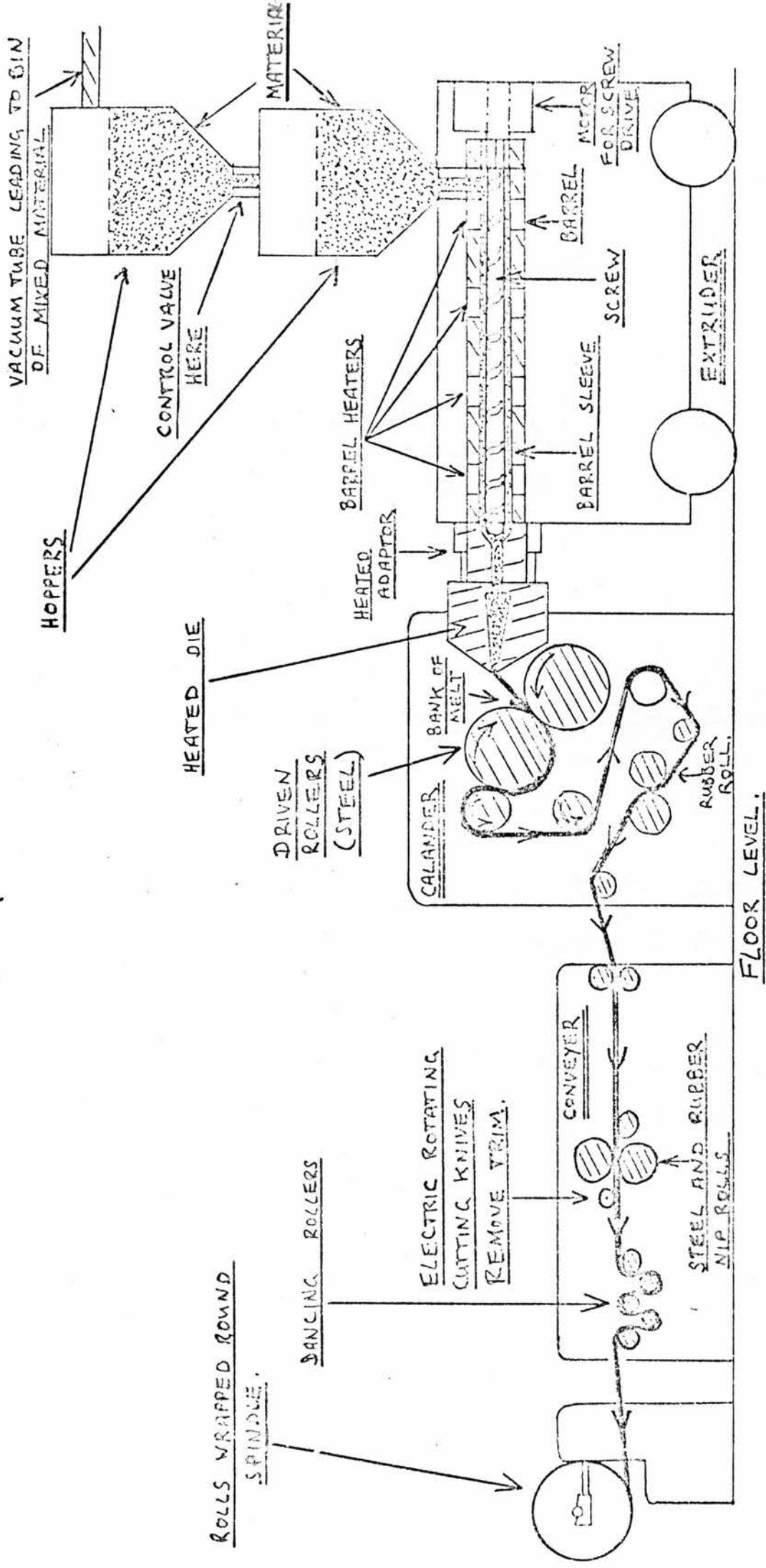


Figure 5.15: Sectional sketch of a Calanderette Extruder (not drawn to scale).

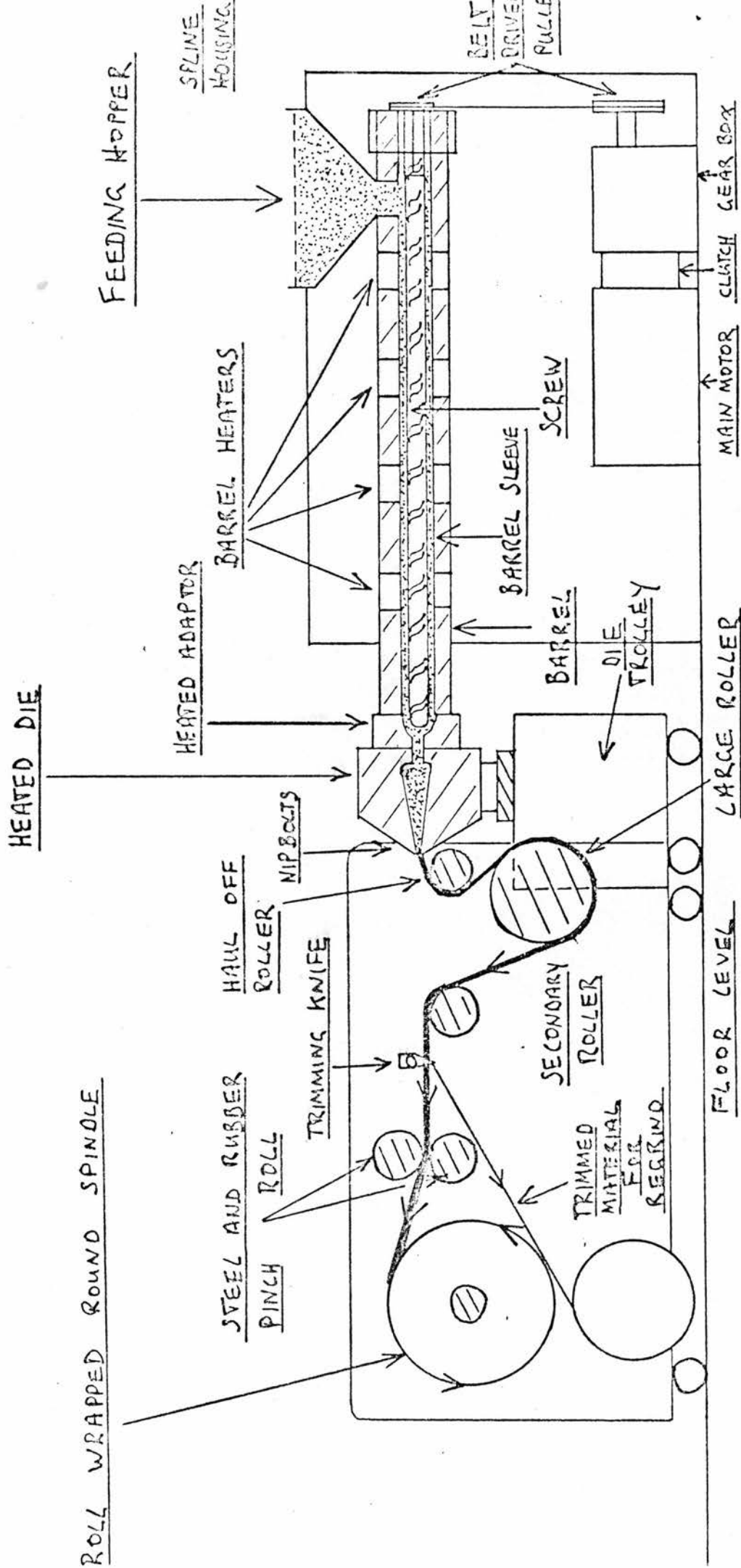


Figure 5.16: Sectional sketch of a Diamat Extruder (not drawn to scale).

drawn over a "haul off roller" and any contamination in the sheet remains. Small particles of dust and other material inevitably find their way into the mixes and when the sheet that carries them reaches a thermo-forming machine, the inserts or tubs do not form properly. Any particle, hole or other weakness in the plastic sheet produces low quality or unusable products.

One Operator controls the calanderette while another looks after the diamats. In order to change from using one type or colour of mix to another, the die, on both types of machine, has to be cleaned. This is a time-consuming task and all those who are available give assistance. Grinding and Mixing Operators may be taken off their machines and the Supervisor and Production Manager help when necessary. Normally, the job of the extruder Operator is rather monotonous and uneventful. Once a machine is set up and running satisfactorily it can generally be left unattended for considerable periods of time. The Operator must be nearby all the time, however, in case anything does start to go wrong. When the machines are running smoothly, one other task that the Operators have to perform other than watching the machines is to periodically remove the plastic roll that has been produced and start winding a fresh one.

The Operators perform a quality check on each roll that is produced. Each roll is weighed and is then checked for three factors:

- (a) shrinkage: the length of a small strip of the plastic cut from the roll is measured before and after immersion in boiling water. Ideally it should shrink by about 8 to 10 per cent. Too little shrinkage is as bad as too

much because the forming machinery and its tooling is designed to cope with shrinkage within certain limits.

- (b) ~~gauge~~: the thickness of the sheet is checked using a micrometer. Different standard thicknesses of material are required for different products.
- (c) width: the width of each roll is measured. The forming machines require material that is wide enough to cover the edges of the moulds used to produce containers, but not so wide as to prevent the sheet entering the machine.

The Production Controller generally schedules work on the extrusion machines one month before the material is required in the forming sections. Rolls of plastic once ready for use are labelled and kept in the roll-store at the rear of the forming area. The output of each extrusion machine is recorded by the Operator who completes a "run sheet" for his shift listing the quantities extruded. This information is given first to the Production Manager who keeps a graph of the output of each machine on his office wall. The run sheets, like the Mixer Operator's daily record sheet, go to the Work Study Department and to the production control section.

The vacuum forming process is carried out as follows. Metal moulds are made by the factory for each type of insert required. The Setter has the tasks of mounting the required mould onto the machine and attaching a roll of the correct material to the end of the machine. Once the machine is in operation, female Operators take over the running. As the plastic sheet is drawn through the vacuum forming machine it is heated and softened. It is pulled in this condition three feet at a time over the mould

in the machine. The air between the mould and each fresh footage of sheet is quickly withdrawn through small holes around the base of the mould itself creating a vacuum that sucks the soft plastic sheet down into the shape of the mould. Hence the name of the process. As the next three feet of plastic is drawn over the mould the sheet just formed is cut off and removed from the machine by an Operator. The forming cycle is usually between 2.5 and 5 seconds. The number of inserts made on any one cycle depends on the size of the individual inserts. These have still to be cut from the sheet and the Operator who removes the sheets from the machine stacks (or "nests") a number of them before passing the stack to the Operator at the cutting table. For each type of insert, the number of sheets that can be cut simultaneously is specified and each time the Operator passes on a stack, she ticks a piece of paper. This is referred to as the "autocount" and it is easy to calculate from this the approximate number of inserts made during a particular run. No allowance is made by the Operator for part - sheets that are scrapped after they have been cut. The Operator who removes the sheets from the machine inspects them briefly and any sheet that has on the whole been badly formed is scrapped. But any sheets that are only partly damaged are passed to the cutting table so that the good inserts can be kept once the sheet is cut up.

The Operator at the cutting table places the nested sheets between two boards that have blades set into them at the intervals appropriate to that product. This sandwich of boards and sheets is passed between a pair of rollers which compress the sandwich and force the blades through the plastic sheets, thus separating the inserts. The Operator takes the inserts out of the boards and

removes the scrap material which is sent back for regrinding.

(See Figure 5.14.)

Another Operator, the packer, stands at the end of the cutting table and puts the inserts into cartons according to given packing instructions designed to ensure that each carton is packed the same way and contains the same number of inserts.

The Chargehand puts a small (pink) ticket onto each carton once it is packed, indicating the contents. She retains a (green) duplicate of this ticket and all the duplicates are gathered at the end of each day and again given to the Work Study Department, and the production control section.

The Supervisors initially allocate Operators to specific tasks on specific machines, but the Operators rotate jobs every two hours throughout the day. The packer goes on to stacking, the stacker goes on to the cutting table and the cutting table Operator takes over the packing. This scheme was introduced in an attempt to alleviate the monotony of these tasks. Sometimes, depending on the order being made, the machine may produce faster than the cutting table or the packer can work. If there are Operators available, two may work at the cutting table and two or more may pack for each machine where this is required. The simplicity of the tasks means that allocation of Operators to tasks and to machines is highly flexible.

The pressure forming process works in a somewhat different way. Again, plastic sheet is drawn over a mould after having been heated and softened. But here a "former" pushes the plastic into the mould to give it the shape required. This process produces sharper definition and greater strength in its products than the

vacuum forming process is capable of. Once the Setters have the machinery working satisfactorily, Operators are moved in to take over. Because the shapes are actually punched out of the sheet, a cutting table is not required and all that the Operators have to do is put the containers into cartons after removing them from the machine. The ticket system used in the vacuum forming section to record output is used here also. The pressure forming process, unlike vacuum forming, does not cut the plastic sheet into three-foot lengths. This process merely punches holes in the sheet, leaving it intact along its length. So that this material can be used again, it must be shredded, by feeding it into a shredding machine. The Setters put this device in motion, but it can be left unattended to gradually pull the used plastic roll through its metal teeth.

The body and lid printing machines are rarely used. Operators are drawn from the vacuum forming section as required. At least two Operators are required for each machine, one to load the items onto the machine (which may print tubs or lids at a rate of up to 6,000 per hour) and one (sometimes two) to remove and pack them into cartons when printed. Supervision may be carried out by a female Supervisor from the vacuum forming section, or by the Production Manager. The ticket system is again used to record output.

All the waste material from the vacuum and pressure forming processes, and trim from extrusion, is taken to the grinding machinery by a Service labourer. Here Operators feed the waste material into two exceptionally noisy machines that grind the waste plastic into a coarse dust. This is put into bins, making sure

not to mix different types of plastic, and this can be fed directly into the extrusion machines or it can be used to make up fresh mixes. After grinding the material is put into bags and weighed. A daily record sheet is again filled in indicating the quantities ground during each shift. This information is passed to the Work Study Department and to the production control section.

Packed cartons of finished goods are taken to the despatch area where, once properly labelled, the pink tickets are removed. These tickets are returned to the production control section to form a record of goods despatched. The company has its own fleet of delivery trucks and vans.

Before passing to Stage 2 of the analysis, the respective roles of the Work Study Department, the Stores and the production control section of the plastics production department will be described in some further detail.* As stated frequently above, all details of daily output are passed to the Work Study Department, where the calculation of wage bonuses is carried out. The production department's budget or "target" is stated in terms of standard hours, and bonus is paid (to all Operators, Chargehands and Supervisors) when this figure is exceeded. In setting the budget suitable allowances are made for time lost in machine breakdown and repairs, material faults and other sources of delay not attributable to the Operators or supervision.

* This information is essential to an understanding of what follows. If the analysis had been carried out in more detail, the relationships between the production department and Work Study and Stores would have been examined in the stages concerning co-ordination between operating systems.

The Work Study Engineers compile a weekly "performance sheet" showing in some detail the output of each section in comparison with its budget. (At the time of writing, this performance sheet covered both tin and plastic container production and no decision had been made as to how this information would be presented for the separate factories.) The performance sheet shows for each section the number of standard hours that should have been achieved during the week, the standard hours actually achieved, the number of man-hours used and the various allowances made for downtime, with reasons. Everyone on both production staff, above Operator level, receives a copy of the weekly performance sheet.

It is also the job of the Work Study Engineers to determine the rate at which orders should be made, and the machines are periodically timed to determine the duration of the forming cycle on each machine for particular orders. It is possible to adjust this speed within small limits, depending upon a number of factors concerning the machine, the product being made and the quality of the plastic material being used.

The Production Controller is primarily responsible for scheduling the work of the production sections, updating the schedules as they deviate from the intended programme, and keeping the Sales Department informed of the progress of orders, particularly those that may be delayed. The Production Control Clerkesses maintain a record of goods despatched and also calculate what are known as "mix variances" and "chemical variances". The main reason for these calculations is to check withdrawals from the stores, but this is also an indicator of the efficiency of the production process.

(a) Chemical Variances:

Knowing the number and type of batches mixed per week, and having copies of the "mix cards", the Production Control Clerkess calculates how much of each chemical should have been used. The Stores Supervisor provides information on the stock levels of each chemical at the beginning and end of each week and by subtraction the Clerkess discovers how much of each chemical has actually been used. The difference between theoretical and actual usage is called the "variance", in this case the "Chemical Variance". There are a number of sources of error mainly due to measurement problems, and in any given week there is always some variance. Over four to six weeks, however, these variances tend to cancel out, indicating that pilfering from the stores is non-existent or negligible and that the measurements are tolerably accurate. Copies of these calculations are distributed weekly to the Technical Director, and his Assistant, the Divisional Manager, the Production Manager (Extrusion), the Administration Manager, the Stores Supervisor and the Consultant Project Engineer.

(b) Mix Variances:

This is a calculation similar to the above which compares the amount of mix that the extrusion section has used with the amount of plastic roll that has been produced. The relevant information comes from the stores stock check and from the extrusion Operators' "run sheets". As explained in the description of the extrusion process, the edges of the plastic sheet are removed and this "trim" accounts for about 12 per cent of the material used. There is also

some slight wastage; the start and finish of each roll is trimmed straight, badly contaminated material is scrapped completely and not reground. The final "yield" should be approximately 85 per cent, i.e. this percentage of material used should end up as finished plastic roll. The calculation shows these assumptions to be reasonably accurate. Copies of these figures are distributed weekly to the Works Director, the Technical Director, the Divisional Manager, and the Production Manager (Extrusion). All the information on variances goes to the Administration Manager for cost calculation purposes.

The work of one other section of the factory requires explanation at this stage - the stores. The stores are run by a Supervisor and two Operators (male). For the ingredients used in the production process, the company chemists have calculated usage rates and derived re-order quantities from these. Twice weekly, the shelves are checked and the amount of each chemical is recorded in the stock file. Once the re-order point is reached the Supervisor contacts the appropriate supplier for the given re-order quantity. There is no stores requisition procedure: plastic roll and chemicals may be removed from the stores freely as required. But as described above, the production control section checks the usage of chemicals and plastic weekly and any pilfering would be quickly detected.

Stage 2 of the Analysis : Identification of Control Factors.

The production department as a whole is divided into a number of sections which have been described above. For the purposes of this analysis, however, the department can be divided into two main

sections; extrusion, mixing and grinding constitutes one of these sections, and vacuum and pressure forming and printing the other. Routine control within the sub-sections of each of these main sections (e.g. of extrusion and mixing, or of vacuum and pressure forming) is almost identical. So to avoid repetition, the department is treated as comprising two sections. They are called "extrusion" and "forming" respectively in the following exposition.

The complete list of control factors arising in and controlled in the plastics production department, and the sections in which they arise, is as follows:

Control factors	Sections
1. Hours of work	Forming
2. Hours of work	Extrusion
3. Quality of materials used	Forming
4. Quality of materials used	Extrusion
5. Department output	Forming
6. Section output	Extrusion
7. Order throughput time	Forming
8. Order throughput time	Extrusion
9. Machine maintenance	Forming
10. Machine maintenance	Extrusion
11. Methods of work	Forming and Extrusion
12. Product quality	Forming
13. Product quality	Extrusion
14. Scrap quantities	Forming
15. Scrap quantities	Extrusion
16. Operator efficiency	Forming
17. Operator efficiency	Extrusion
18. Task Distribution within sections	Forming
19. Task Distribution within sections	Extrusion
20. Task Distribution between sections	Forming
21. Task Distribution between sections	Extrusion
22. Material costs	Forming and Extrusion
23. Labour costs	Forming and Extrusion
24. Other costs	Forming and Extrusion
25. Floor layout	Forming and Extrusion
26. Size of work force	Forming and Extrusion

Stage 3 of the Analysis : The Routine Control Operations.

The routine control operations for the above 26 control factors are described in brief in the pages that follow. Job titles that have been underlined are those which appear in the routine control grid which summarises these operations. This grid is shown in Figure 5.17.

Stage 4 of the Analysis : The Planning Control Operations.

The planning control operations are summarised in Figure 5.18. These operations are carried out for the Department as a whole, and no distinction is made in Figure 5.18 between the forming and extrusion sections. There is, therefore, a total of 16 control factors listed in Figure 5.18.

Stage 5 of the Analysis : Primary Decision Making.

The primary decision making operations are summarised in Figure 5.19. Although it is now a wholly owned subsidiary of Scotcros Ltd., Wilkie and Paul has retained virtual autonomy and still has a member of the original owners' family on the Board of Directors; R.B. Paul is the Managing Director.

	<p style="text-align: center;">1. Hours of work, Forming</p> <p>The <u>Supervisor</u> gives the Personnel Manageress a daily list of late-comers and absentees. The <u>Personnel Assistant</u> keeps a permanent record of this. The <u>Production Manager</u> and <u>Divisional Manager</u> monitor the total number of hours worked with respect to the department output.</p>
<p>Measurement</p>	<p>The <u>Personnel Manageress</u> determines the severity of each individual case of poor timekeeping or attendance.</p> <p>The <u>Production Manager</u> and <u>Divisional Manager</u> determine the adequacy of the total number of hours worked to meet the budgeted output.</p>
<p>Comparison</p>	<p>The <u>Personnel Manageress</u> may decide to take no immediate action, issue a reprimand, or dismiss. The <u>Production Manager</u> and <u>Divisional Manager</u> decide whether or not to alter the hours of working of the factory, with the advice of the Personnel Manageress. To increase output, more overtime may be sanctioned; to obtain extra labour, special shifts may be arranged such as those which suit married women with young children.</p>
<p>Decide Action</p>	<p>The <u>Personnel Manageress</u> reprimands or dismisses Operators personally. The <u>Production Manager</u>, along with the Personnel Manageress, ensures that any alterations to working hours are adhered to. He may have to find extra Operators willing to work more overtime.</p>

	<p style="text-align: center;">2. Hours of work, Extrusion</p>
Measurement	<p>The <u>Supervisor</u> reports any absenteeism or poor timekeeping to the Personnel Manageress. The <u>Personnel Assistant</u> keeps a permanent record of this. The <u>Production Manager</u> and <u>Divisional Manager</u> monitor the total number of hours worked with respect to the department output.</p>
Comparison	<p>The <u>Personnel Manageress</u> determines the severity of each individual case of poor timekeeping or attendance. The <u>Production Manager</u> and <u>Divisional Manager</u> determine the adequacy of the total number of hours worked to meet the budgeted output.</p>
Decide Action	<p>The <u>Personnel Manageress</u> decides whether to take no action, issue a reprimand, or dismiss. The <u>Production Manager</u> and <u>Divisional Manager</u> decide whether or not to alter the hours of working of the factory, with the advice of the Personnel Manageress. To increase output, more overtime and weekend working for maintenance or repair workers may be sanctioned.</p>
Take Action	<p>The <u>Personnel Manageress</u> reprimands or dismisses. The <u>Production Manager</u>, along with the Personnel Manageress, ensures that any alterations to working hours are adhered to.</p>

	<p>3. Quality of material used, Forming</p>
Measurement	<p><u>Operators</u> on the forming machines detect poor material as inserts come off the machines. If a few bad inserts are being made, they are scrapped; but if a lot of inserts are not forming correctly, the Operator informs the Chargehand or a Supervisor.</p>
Comparison	<p>The <u>Chargehand</u> decides whether or not the material is bad enough to require replacement. A <u>Supervisor</u> is informed if a machine may have to be stopped, and the <u>Production Manager</u> is consulted in more serious or difficult situations.</p>
Decide Action	<p>The <u>Supervisor</u> and/or <u>Production Manager</u> decide whether or not to replace faulty material; it may be possible to obtain some good inserts from an otherwise poor roll. Advice may be sought from the <u>Production Manager (Extrusion)</u>, the <u>Technical Director</u> and the <u>Materials Engineer</u> regarding the suitability of available material for particular orders.</p>
Take Action	<p>A <u>Setter</u> replaces the faulty plastic roll as required.</p>

	<p>4. Quality of material used, Extrusion</p>
Measurement	<p>Mixes are tested for suitability before being put into standard production and are not normally tested before actual use. The Mixer Operator is expected to adhere to the "recipe" exactly. Incorrect mixes are rare - they are detected as the plastic sheet comes through the machine. See PRODUCT QUALITY.</p>
Comparison	<p>-- --</p>
Decide Action	<p>-- --</p>
Take Action	<p>-- --</p>

<p>5. Department output, Forming</p>	<p>For each pallet full of packed cartons, a <u>Chargehand</u> writes a ticket showing the quantity produced. The ticket is affixed to the pallet and all copies are collected daily and given to the <u>Assistant Production Controller</u>. The latter logs these amounts in the "stock file" and entries are checked off as the goods are despatched. A <u>Work Study Engineer</u> is also given a copy of daily output figures for the bonus calculation.</p>	<p>The <u>Production Controller</u> monitors output levels to ensure that they are adequate. The <u>Production Managers</u> and <u>Divisional Manager</u> are made aware of the current situation by the <u>Production Controller</u>.</p>	<p>The <u>Production Controller</u> can re-schedule jobs and keep the machinery operating if any particular job has to be stopped (perhaps due to bad material). The <u>Production Manager</u> is usually consulted when it appears that this will have to be done; and in serious cases, the <u>Divisional Manager</u> may contribute a solution. He may authorise extra overtime to bring output up to the required level.</p>	<p>Any alterations to the scheduled programme are made by the <u>Production Controller</u> who prepares a new schedule and issues it to the <u>Supervisors</u> who put it into effect.</p>
Measurement	Comparison	Decide Action	Take Action	

	<p>6. Section output, Extrusion</p>
Measurement	<p>The <u>Extruder Operators</u> complete a "run sheet" for each roll of plastic made. The <u>Mixer and Grinder Operators</u> complete a "daily sheet" indicating the quantities mixed and reground each day. The <u>Production Manager</u> collects these sheets daily and transmits this information to a <u>Work Study Engineer</u> and the <u>Assistant Production Controller</u>.</p>
Comparison	<p>The <u>Production Controller</u> keeps a daily check on output to ensure that it is adequate. The <u>Production Manager</u> and the <u>Divisional Manager</u> are made aware of the current situation by the <u>Production Controller</u>.</p>
Decide Action	<p>The <u>Production Controller</u> can re-schedule jobs to keep machinery running if any particular job is delayed. The <u>Production Manager</u> is consulted if this is done, and in extreme cases the <u>Divisional Manager</u> may have to decide what action to take; e.g., to decide which of two important jobs to run first.</p>
Take Action	<p>All programme alterations are made and circulated by the <u>Production Controller</u> and the <u>Supervisor</u> sees this put into effect.</p>

	<p>7. Order throughput time, Forming</p>
Measurement	<p>The <u>Chargehands</u> discover delays through the "hourly count" (see Operator Efficiency), or when a machine is stopped for any reason. The <u>Supervisors</u> know by the running output total they keep on the back of each "order progress sheet" how near an order is to completion. The <u>Production Controller</u> has an overall view of the department's output performance on his "load board".</p>
Comparison	<p>The <u>Chargehands</u> and <u>Supervisors</u> decide if there is anything they can do to speed up production. The <u>Production Manager</u> is informed if an order is going to be significantly delayed; and the <u>Production Controller</u> may be required to do some re-scheduling.</p>
Decide Action	<p>The <u>Chargehands</u> and <u>Supervisors</u> decide on any action which they consider appropriate. In more serious cases, the <u>Production Manager</u> is required to provide a solution, and the <u>Divisional Manager</u> may also be involved; they may decide to re-run a job with different material, or to work extra overtime to complete an order in time. The <u>Production Controller</u> decides what action is necessary if any re-scheduling is required.</p>
Take Action	<p><u>Chargehands</u> may reprimand Operators for slacking, and may even give assistance to clear work; <u>Supervisors</u> may also reprimand or place Operators on different jobs or machines; the <u>Production Controller</u> draws up any new programmes necessary and issues them to the Supervisors; if different material is needed, the <u>Setters</u> ensure that it is mounted onto the machines.</p>

8. Order throughput time, Extrusion

The Supervisor notes any delays as they occur. He can tell from the weekly programme whether a particular job is being delayed or not. The Production Controller who issues these programmes has an overall view of the department's output performance on his "load board".

The Supervisor decides whether or not any action can be taken to prevent or shorten a delay. The Production Manager is consulted in more serious cases and the Production Controller may have to re-schedule some orders.

The Supervisor may decide what action can be taken to prevent delay. The Production Manager may have to decide on appropriate action, as may the Divisional Manager in cases of really serious delay. It is possible to use different materials for specific jobs; jump ahead of schedule until the job that was stopped can be re-started, perhaps with a better mix. The Production Controller decides upon the requisite re-scheduling.

The Supervisor arranges for other jobs to be run if required. The Production Controller draws up and circulates revised programmes.

Measurement

Comparison

Decide Action

Take Action

	<p>9. Machine maintenance, Forming</p>
Measurement	<p>An <u>Operator</u> is usually the first to detect a machine breakdown. The Operator either calls for a maintenance man or contacts a <u>Chargehand</u> or <u>Supervisor</u> who will do this. The <u>Work Study Engineers</u> prepare a "weekly performance sheet" for all sections indicating their respective amounts of down-time and the reasons for each occurrence.</p>
Comparison	<p>A <u>Setter</u> has the first attempt to repair a breakdown. If he cannot, he asks a <u>Maintenance Operator</u> or <u>Electrician</u> to repair the machine, depending on what is wrong with it. The <u>Production Manager</u> investigates any recurring problems detected from the "weekly performance sheet".</p>
Decide Action	<p>Depending on the fault that has developed, the <u>Setter</u> or the <u>Maintenance Operator</u> or the <u>Electrician</u> will decide what to do about it. The <u>Production Manager</u> and/or <u>Divisional Manager</u> are consulted when major breakdowns occur; they decide what action to take to remedy any recurring problems.</p>
Take Action	<p>Depending on the fault that has developed, the <u>Setter</u> or the <u>Maintenance Operator</u> or the <u>Electrician</u> will repair it. The <u>Supervisors</u> are responsible for preventing the reoccurrence of faults where possible. They may give Operators additional instruction.</p>

	<p>10. Machine maintenance, Extrusion</p>
Measurement	<p><u>Operators</u> note any malfunctioning or breakdown of machinery. (A special emergency procedure is initiated to close down and protect the extrusion machinery - they are filled with polystyrene to prevent damage.) The <u>Work Study Engineers</u> prepare a "weekly performance sheet" for all sections indicating their respective amounts of down-time and the reasons for each occurrence.</p>
Comparison	<p>The <u>Supervisor</u> is informed and he examines the situation; he may call for a <u>Maintenance Operator</u> or an <u>Electrician</u> to inspect the trouble. If it is serious or liable to be time consuming, the <u>Production Manager</u> is informed. The <u>Production Manager</u> also investigates any recurring problems detected from the "weekly performance sheet".</p>
Decide Action	<p>The <u>Supervisor</u> decides what should be done if he can. If not, the <u>Maintenance Operator</u> or <u>Electrician</u> will decide what to do. The <u>Production Manager</u> may decide what action should be taken in more serious cases, especially those involving significant loss of production. The <u>Divisional Manager</u> may also be involved where recurring breakdowns are reducing output significantly.</p>
Take Action	<p>The <u>Supervisor</u>, and sometimes the <u>Production Manager</u> assist the <u>Operators</u> when any large maintenance tasks arise, such as a die-clean. The <u>Supervisor</u> undertakes any repairs he is able to do himself. A <u>Maintenance Operator</u> or <u>Electrician</u> effect all other repairs and maintenance work. The <u>Supervisors</u> are also responsible for preventing the reoccurrence of faults where possible. They may give <u>Operators</u> more instruction.</p>

	11. Methods of work, Forming and Extrusion
Measurement	---
Comparison	---
Decide Action	<p>The tasks involved, and the sequence in which they must be performed are completely determined by the technology of the production process.</p>
Take Action	---

	<p>12. Product quality, Forming</p> <p><u>Operators</u> inspect the inserts as they come off the machines, and the cutters and packers perform a similar visual check. Occasionally a <u>Chargehand</u> checks that the <u>Operators</u> are doing this properly. The <u>Supervisors</u> also make periodic inspections.</p>
Measurement	<p><u>Operators</u> decide if any sheet or single inserts are of inferior quality. If doubtful, a <u>Chargehand</u> or <u>Supervisor</u> will be asked. Sometimes, a good insert of the type being made is taped to the side of the machine to compare with those being made. If a <u>Supervisor</u> is not certain, she may contact the <u>Production Manager</u> and the <u>Sales Manager</u>.</p>
Comparison	<p>The <u>Operators</u> decide which inserts to scrap and which to pack. In cases of doubt, the <u>Chargehand</u>, <u>Supervisor</u>, <u>Production Manager</u> and <u>Sales Manager</u> may each in turn be asked for a final decision. With an important order, the <u>Divisional Manager</u> may have to decide.</p>
Decide Action	<p>There are scrap bins beside all machines into which the <u>Operators</u> place reject items.</p>
Take Action	

	<p>13. Product quality, Extrusion</p> <p>The mix quality is not checked before use, neither is the material which is re-ground. The <u>extruder Operators</u> perform width, gauge and shrinkage tests on each roll of plastic as it is made. A record is kept of this information until the roll is used in the forming department.</p>
Measurement	<p>The <u>Operator</u> may decide whether the machine controls require adjustment to improve the quality of roll produced.</p> <p>The <u>Supervisor</u> is informed when anything serious or unusual occurs</p>
Comparison	<p>The <u>Operator</u> may decide which controls to adjust to improve roll quality. The <u>Supervisor</u> can decide what action to take in more serious cases, and the <u>Production Manager</u> is consulted particularly when production may be lost.</p>
Decide Action	<p>The <u>Operators</u> make any necessary adjustments to the machines.</p>
Take Action	

	<p>14. Scrap quantities, Forming</p>
Measurement	<p>A <u>Grinder Operator</u> weighs all material that has been re-ground. The totals are recorded on a "daily sheet" which is given to the <u>Assistant Production Controller</u> for the calculation of "variances". A weekly report is typed and circulated.</p>
Comparison	<p>The appearance of excessive scrap quantities is investigated by the <u>Production Controller</u>. Through the weekly report the <u>Production Manager</u> and <u>Divisional Manager</u> may take an interest.</p>
Decide Action	<p>The <u>Production Controller</u> may decide to remedy the situation. Excess scrap can be produced by poor material, faulty tooling, or even miscalculation of the quantities involved (he may request that a stock check be performed). Depending on the seriousness of the case, the <u>Production Manager</u> and/or the <u>Divisional Manager</u> may be required to decide upon appropriate corrective action.</p>
Take Action	<p>The <u>Production Manager</u> ensures that the causes are remedied; he may order new material, or re-tooling of the machines. Any re-scheduling of production is done by the <u>Production Controller</u>.</p>

	<p>15. Scrap quantities, Extrusion</p>
Measurement	<p>Trim from the extrusion process is re-ground with scrap from the forming department and it is all weighed together by a <u>Grinder Operator</u>. Totals are sent daily to the <u>Assistant Production Controller</u> for the calculation of "variance" on which a weekly report is typed and circulated.</p>
Comparison	<p>The report shows the difference between the amount of mix used and plastic roll produced. Any abnormal difference is investigated by the <u>Production Controller</u>. The <u>Production Manager</u> and <u>Divisional Manager</u> receive copies of this report and may decide to investigate for themselves.</p>
Decide Action	<p>The <u>Production Controller</u> can decide to remedy the situation; the quantities involved may have been miscalculated. The <u>Technical Director</u> is consulted if the basic ingredients of mixes have to be altered. The <u>Production Manager</u> and <u>Divisional Manager</u> may decide upon any other corrective action that can be taken. There may be a machine or its mode of operation at fault.</p>
Take Action	<p>The <u>Production Manager</u> carries out any action deemed necessary. He may delegate this task to the <u>Supervisor</u>; an Operator may require further instruction, a machine may require more accurate setting. All re-scheduling is done by the <u>Production Controller</u>; it is desirable to avoid producing 10 inch wide roll through a 22 inch wide die, and to alter a die is time consuming. The <u>Materials Engineer</u> may have to re-formulate a mix.</p>

	<p>16. Operator efficiency, Forming</p>
Measurement	<p>The <u>Chargehands</u> take an "hourly count" of the output of each machine. This is chalked onto a board at the side of the area. The board indicates the number of cartons that should be packed per hour, and the number that have been packed. The <u>Supervisors</u>, who train all the female Operators, know how good each one is.</p>
Comparison	<p>The <u>Chargehands</u> decide if any situation warrants remedial action. The <u>Supervisors</u> also monitor the Operator's performance. If they are not certain whether anything should be done, they consult the <u>Production Manager</u>.</p>
Decide Action	<p>The <u>Chargehands</u> and/or <u>Supervisors</u> decide what action to take. The <u>Production Manager</u> deals with serious cases and the <u>Divisional Manager</u> is consulted if an endorsement is to be given (see below). If dismissal is considered, the <u>Personnel Manageress</u> must be consulted.</p>
Take Action	<p><u>Chargehands</u> or <u>Supervisors</u> may reprimand Operators. <u>Supervisors</u> or the <u>Production Manager</u> may place Operators on different jobs. For more serious cases there is an "endorsement system"; the Operator's time card is endorsed for each infringement. The <u>Production Manager</u> issues this. The fourth endorsement leads to automatic dismissal. The <u>Personnel Manageress</u> deals with all dismissals.</p>

	<p>17. Operator efficiency, Extrusion</p>
Measurement	<p>The <u>Supervisor</u> is responsible for the satisfactory performance of the Operators. He is continually present in the area. On-the-job training for Operators gives the Supervisor a knowledge of their respective abilities. The <u>Work Study Engineers</u> calculate the "standard hours" achieved per day, but this also depends to a large extent on the satisfactory running of the machinery, often outwith the Operator's control.</p>
Comparison	<p>The <u>Supervisor</u> decides whether action is necessary to improve an Operator's work. He may ask the <u>Production Manager</u> to examine any particularly serious case, perhaps if he wishes the Operator removed from his group.</p>
Decide Action	<p>The <u>Supervisor</u> decides what action is necessary to improve an Operator's work. The <u>Production Manager</u> decides what action to take in more serious cases. An Operator may be moved to a different job. The endorsement system is used as in the forming department, involving the <u>Divisional Manager</u>. If an Operator may be dismissed, the <u>Personnel Manageress</u> is consulted.</p>
Take Action	<p>The <u>Supervisor</u> may reprimand an Operator for slack work, or move him to another job on the Production Manager's instructions. The <u>Production Manager</u> issues endorsements when required. The <u>Personnel Manageress</u> deals with all dismissals.</p>

	<p>18. Task distribution within sections, Forming</p>
Measurement	<p>One of the <u>Supervisors</u> allocates Operators to jobs each Monday morning. The Operators rotate jobs every 2 hours. A <u>Chargehand</u> is normally the first to discover if a machine is under or over staffed.</p>
Comparison	<p>The <u>Chargehands</u> bring any under or over staffing to the attention of the <u>Supervisors</u> who decide if anything should be done.</p>
Decide Action	<p><u>Supervisors</u> normally decide where to allocate Operators and where to reallocate them when necessary. The <u>Production Manager</u> decides difficult issues, say where there are not enough Operators to cover the machines working two important orders simultaneously.</p>
Take Action	<p><u>Chargehands</u> and <u>Supervisors</u> ensure that allocations and reallocations are carried out.</p>

	<p>19. Task distribution within sections, Extrusion</p> <p>The <u>Supervisor</u> monitors the work load of each section. There is a reasonable degree of flexibility between Operators, most of whom can perform or assist with most tasks in the department when necessary.</p>
Measurement	<p>The <u>Supervisor</u> decides whether any reallocation of Operators would be useful.</p>
Comparison	<p>The <u>Supervisor</u> decides what reallocations to make; the Mixer or Grinder Operators assist in die-cleaning the extrusion machines; the extruder Operators can work the grinders if required, or help to move material.</p>
Decide Action	<p>The <u>Supervisor</u> reallocates the Operators involved.</p>
Take Action	

	<p>20. Task distribution between sections, Forming</p>
Measurement	<p>If machinery in one section breaks down, <u>Chargehands</u> and <u>Supervisors</u> are the first to know about it. This means that <u>Operators</u> may have no work for some time and they could be used in the other section, moved from pressure forming to vacuum forming and vice versa.</p>
Comparison	<p>The <u>Supervisors</u> consider whether reallocations might be worthwhile and inform the <u>Production Manager</u> who also examines the circumstances.</p>
Decide Action	<p>The <u>Production Manager</u> decides if it is feasible to move <u>Operators</u> to the other section. This depends on the respective work loads of the sections and the length of down time expected.</p>
Take Action	<p>A <u>Supervisor</u> makes out a "transfer card" for each <u>Operator</u> involved. This is done to ensure that the correct rate of pay is given for the job.</p>

	<p>21. Task distribution between sections, Extrusion</p> <p>The <u>Supervisor</u> is responsible for identifying situations where this may be done. If the department has a power failure or a machine is to be out of action for a considerable time, Operators may be moved into the forming department.</p>
Measurement	<p>The <u>Supervisor</u> may decide on his own whether any action should be taken. He may consult the <u>Production Manager</u>.</p>
Comparison	<p>The <u>Supervisor</u> may decide what action should be taken, how many Operators to move, where to put them. The <u>Production Manager</u> may participate in the decision; one of the extruder Operators is a trained vacuum forming machine Setter, most of the other Operators are familiar with the work of the forming department.</p>
Decide Action	<p>The <u>Supervisor</u> writes out a transfer card for each Operator concerned. This is done to ensure that the correct wage rate is paid for the different jobs.</p>
Take Action	

<p>22. Material costs, Forming and Extrusion</p>	<p>The <u>Cost Accountant</u> compiles statements on the cost of materials used from information received from the Production Control section. Weekly and monthly reports are circulated.</p>
<p>Measurement</p>	<p>The <u>Production Manager</u> and <u>Divisional Manager</u> monitor these reports to detect any anomalies in materials costs.</p>
<p>Comparison</p>	<p>Any excessive rises in costs are investigated by the <u>Production Manager</u> and/or the <u>Divisional Manager</u> who decide what action can be taken. The <u>Technical Director</u> and <u>Sales Director</u> may be consulted if a change to a different, perhaps cheaper material is being considered.</p>
<p>Decide Action</p>	<p>The <u>Production Manager</u> ensures that the necessary action is undertaken.</p>
<p>Take Action</p>	

	<p>23. Labour costs, Forming and Extrusion</p>
Measurement	<p>The <u>Work Study Clerkess</u> uses the daily returns to compute the standard hours achieved for bonus calculation, and the number of man-hours clocked up ("clock hours"). The <u>Cost Accountant</u> compiles statements of actual expenditure, but the standard and clock hours figures are the ones generally used.</p>
Comparison	<p>The <u>Production Manager</u> and <u>Divisional Manager</u> receive, from the Work Study Department, daily statements of the previous day's performance in terms of standard hours and clock hours. They decide whether the figures indicate that action may be necessary.</p>
Decide Action	<p>The <u>Divisional Manager</u> decides what action is necessary to reduce labour costs. The amount of overtime may be reduced, rather than cut the labour force.</p>
Take Action	<p>The <u>Production Manager</u> is responsible for seeing that the appropriate action is undertaken.</p>

	<p>24. Other costs, Forming and Extrusion</p>
Measurement	<p>The <u>Cost Accountant</u> arranges payment and maintains records of all overheads (electricity costs, earplugs, floor cleaning equipment etc.).</p>
Comparison	<p>The <u>Production Manager</u> and <u>Divisional Manager</u> receive monthly statements from the Cost Department on cost levels and they decide if any action is necessary.</p>
Decide Action	<p>The <u>Production Manager</u> and <u>Divisional Manager</u> decide on means of reducing excessive or rising costs. It is often possible to restrict the use of non-essential items, at least temporarily.</p>
Take Action	<p>The <u>Production Manager</u> is responsible for seeing that the necessary action is undertaken.</p>

	<p>25. Floor layout, Forming and Extrusion</p>
Measurement	<p>The <u>Work Study Engineers</u> maintain plans of the factory layout.</p>
Comparison	<p>Anyone working around the shop floor, above Operator level, is likely to indicate where possible improvements might be made. The <u>Work Study Engineers</u> collate any such suggestions and their own opinions, and decide if any alterations would be useful.</p>
Decide Action	<p>The <u>Industrial Engineer</u> and the <u>Work Study Engineers</u> decide what improvements to the layout should be made. The opinions of the <u>Divisional Manager</u> carry some considerable weight. The <u>Works Director</u> is concerned where major changes are to be made.</p>
Take Action	<p>The <u>Work Study Engineers</u> prepare the final plans and put alterations into effect.</p>

26. Size of workforce, Forming and Extrusion

The Personnel Assistant maintains a file of all employees. The Production Manager monitors the size of the work force with respect to the department's output.

The Personnel Assistant amends this file as employees leave or are hired. The Production Manager determines the adequacy of the work force to meet the budget required.

The Personnel Manageress determines recruitment methods and is responsible for dismissals. The Production Manager decides whether more labour or less is required. He completes a requisition form which is given to the Personnel Manageress. The Production Manager may normally increase the work force up to the budgeted expenditure limit, unless the Personnel Manageress contests his claim.

The Personnel Manageress interviews prospective employees to determine their suitability. Candidates are then interviewed by the Production Manager and sometimes by the Divisional Manager also. The Personnel Manageress is responsible for dismissals. The Personnel Assistant deals with advertisement placement and other administrative details.

Measurement

Comparison

Decide Action

Take Action

Figure 5.17a*: Routine control grid for Wilkie and Paul Plastics
Production Department.

SECTION	Extrusion/Forming.	Forming.	Extrusion.	Forming.	Extrusion.
CONTROL FACTORS CONTROL OPERATIONS	Hours of Work	Quality of Materials	Quality of Materials	Output	Output
MEASUREMENT	Supervisor, Personnel assistant, Production Manager, Divisional Manager.	Operators.		Chargehands, Assistant Production Controller, Work Study Engineer.	Operators, Production Manager, Work Study Engineer, Assistant Production Controller.
COMPARISON	Personnel Manageress, Production Manager, Divisional Manager.	Chargehand, Supervisor, Production Manager.		Production Controller, Production Manager, Divisional Manager.	Production Controller, Production Manager, Divisional Manager.
DECIDE ACTION	Personnel Manageress, Production Manager, Divisional Manager.	Supervisor, Production Manager, Technical Director, Materials Engineer.	Not controlled.	Production Controller, Production Manager, Divisional Manager.	Production Controller, Production Manager, Divisional Manager.
TAKE ACTION	Personnel Manageress, Production Manager.	Setter.		Supervisor, Production Controller.	Supervisor, Production Controller.

*This Figure is in five parts, lettered a to e.

Figure 5.17b: Routine control grid for Wilkie and Paul Plastics
Production Department, continued.

SECTION	Forming.	Extrusion.	Forming.	Extrusion.	Forming/Extrusion.
CONTROL FACTORS	Throughput Time	Throughput time	Machine Maintenance	Machine Maintenance	Methods of work
CONTROL OPERATIONS					
MEASUREMENT	Chargehand, Supervisor, Production Controller.	Supervisor, Production Controller.	Operator, Chargehand, Supervisor, Work Study Engineer.	Operator, Work Study Engineer.	
COMPARISON	Chargehand, Supervisor, Production Controller, Production Manager.	Supervisor, Production Manager, Production Controller.	Setter, Maintenance Operator, Electrician, Production Manager.	Supervisor, Maintenance Operator, Electrician, Production Manager.	
DECIDE ACTION	Chargehand, Supervisor, Production Controller, Production Manager, Divisional Manager.	Supervisor, Production Controller, Production Manager, Divisional Manager.	Setter, Maintenance Operator, Electrician, Production Manager, Divisional Manager.	Maintenance Operator, Electrician, Supervisor, Production Manager, Divisional Manager.	Not controlled, determined entirely by technology.
TAKE ACTION	Setter, Chargehand, Supervisor, Production Controller.	Supervisor, Production Controller.	Setter, Maintenance Operator, Electrician, Supervisor.	Operator, Maintenance Operator, Electrician, Supervisor, Production Manager.	

Figure 5.17c: Routine control grid for Wilkie and Paul Plastics
Production Department, continued.

SECTION	Forming.	Extrusion.	Forming.	Extrusion.	Forming
CONTROL FACTORS CONTROL OPERATIONS	Product Quality	Product Quality	Scrap Quantities	Scrap Quantities	Operator Efficiency
MEASUREMENT	Operator, Chargehand, Supervisor.	Operator.	Operator (Grinding), Assistant Production Controller.	Operator (Grinding), Assistant Production Controller.	Chargehand, Supervisor.
COMPARISON	Operator, Chargehand, Supervisor, Production Manager, Sales Manager.	Operator, Supervisor.	Production Controller, Production Manager, Divisional Manager.	Production Controller, Production Manager, Divisional Manager.	Chargehand, Supervisor, Production Manager.
DECIDE ACTION	Operator, Chargehand, Supervisor, Production Manager, Divisional Manager, Sales Manager.	Operator, Supervisor, Production Manager.	Production Controller, Production Manager, Divisional Manager.	Production Controller, Production Manager, Divisional Manager, Technical Director.	Chargehand, Supervisor, Production Manager, Divisional Manager, Personnel Manageress.
TAKE ACTION	Operator.	Operator.	Production Controller, Production Manager.	Supervisor, Production Controller, Production Manager, Materials Engineer.	Chargehand, Supervisor, Production Manager, Personnel Manageress.

Figure 5.17d: Routine control grid for Wilkie and Paul Plastics
Production Department, continued.

SECTION	Extrusion.	Forming.	Extrusion.	Forming.	Extrusion.
CONTROL FACTORS CONTROL OPERATIONS	Operator Efficiency	Task Distribution Within Sections	Task Distribution Within Sections	Task Distribution Between Sections	Task Distribution Between Sections
MEASUREMENT	Supervisor, Work Study Engineer.	Chargehand, Supervisor.	Supervisor.	Chargehand, Supervisor.	Supervisor.
COMPARISON	Supervisor, Production Manager.	Chargehand, Supervisor.	Supervisor.	Supervisor, Production Manager.	Supervisor, Production Manager.
DECIDE ACTION	Supervisor, Production Manager, Divisional Manager, Personnel Manageress.	Supervisor, Production Manager.	Supervisor.	Production Manager.	Supervisor, Production Manager.
TAKE ACTION	Supervisor, Production Manager, Personnel Manageress.	Chargehand, Supervisor.	Supervisor.	Supervisor.	Supervisor.

Figure 5.17e: Routine control grid for Wilkie and Paul Plastics
Production Department, continued.

SECTION	Forming/Extrusion.	Forming/Extrusion.	Forming/Extrusion.	Forming/Extrusion.	Forming/Extrusion.
CONTROL FACTORS CONTROL OPERATIONS	Material Costs	Labour Costs	Other Costs	Factory Layout	Size of Work Force.
MEASUREMENT	Cost Accountant.	Work Study Clerkess, Cost Accountant.	Cost Accountant.	Work Study Engineers.	Personnel Assistant, Personnel Manageress.
COMPARISON	Production Manager, Divisional Manager.	Production Manager, Divisional Manager.	Production Manager, Divisional Manager.	Work Study Engineers.	Personnel Assistant, Personnel Manageress.
DECIDE ACTION	Production Manager, Divisional Manager, Technical Director, Sales Director.	Divisional Manager.	Production Manager, Divisional Manager.	Work Study Engineers, Industrial Engineer, Divisional Manager, Works Director.	Personnel Manageress, Production Manager.
TAKE ACTION	Production Manager.	Production Manager.	Production Manager.	Work Study Engineers.	Production Manageress, Production Manager, Personnel Assistant, (Divisional Manager on occasion.)

Figure 5.18a*: Planning control grid for Wilkie and Paul Plastics
Production Department.

CONTROL FACTORS CONTROL OPERATIONS	Quality of material used	Size of work force	Hours of work	Output
INFORMATION SOURCES	No permanent records held. Records of quality of plastic rolls held until rolls have been used.	Personnel Department records.	Records of hours worked kept by Personnel Assistant, based on the Supervisors' "daily lists". Work Study Engineers record actual man hours worked, allowing for machine down-time.	Assistant Production Controller's "stock file", and record of despatches. (Assistant Production Controller also collates figures showing daily output of Extrusion section.)
SET STANDARD	<p style="text-align: center;">The Board of Directors approves and reviews all operating procedures and evaluates alternatives.</p> <p style="text-align: center;">(The Board comprises: Managing Director, Works Director, Technical Director, and Sales Director.)</p>			
MEASUREMENT	Production Manager, Divisional Manager, Technical Director.	Production Manager, Divisional Manager.	Production Manager, Divisional Manager.	Production Manager, Divisional Manager.
COMPARISON	<p style="text-align: center;">Divisional Manager, Works Director and Managing Director.</p>			
DECIDE ACTION	Divisional Manager and Board of Directors.	Operators: Extrusion section Operators decided on current shift system, Divisional Manager, Board of Directors.		Divisional Manager, Board of Directors.
TAKE ACTION	<p style="text-align: center;">Production Manager and Divisional Manager.</p>			

*This Figure is in four parts, lettered a to d.

Figure 5.18b: Planning control grid for Wilkie and Paul Plastics
Production Department, continued.

CONTROL FACTORS CONTROL OPERATIONS	Order throughput time	Machine maintenance	Methods of work	Product quality
INFORMATION SOURCES	Production Controller's load board, and records of orders received and despatches.	"Weekly Performance Sheet" compiled by Work Study Engineers indicates amounts of machine down-time and reasons.	Work Study Engineers.	No permanent records. Records of quality of plastic rolls held until rolls have been used.
SET STANDARD	: : : The Board of Directors approves and reviews all operating procedures and evaluates alternatives. (The Board comprises: Managing Director, Works Director, Technical Director, and Sales Director.) : : :			
MEASUREMENT	Production Manager, Divisional Manager.	Production Manager, Divisional Manager.	Production Manager, Divisional Manager, Industrial Engineer.	Production Manager, Divisional Manager, Technical Director.
COMPARISON	: : : Divisional Manager, Works Director and Managing Director. : : :			
DECIDE ACTION	: : : : : : Divisional Manager and Board of Directors. : : :			
TAKE ACTION	Production Manager and Divisional Manager.		Production Manager, Divisional Manager, Work Study Engineers, Industrial Engineer	Production Manager, Divisional Manager.

Figure 5.18c: Planning control grid for Wilkie and Paul Plastics
Production Department, continued.

CONTROL FACTORS CONTROL OPERATIONS	Scrap quantities	Operator efficiency	Task distribution within sections	Task distribution between sections
INFORMATION SOURCES	Assistant Production Controller's weekly "variance" reports.	Work Study Engineers' weekly performance sheet; not a reliable indicator - output and productivity dependent mainly on efficiency of machinery.	No records.	Administration section keeps "transfer cards" for Operators that have been moved; these cards are kept for payment purposes.
SET STANDARD	The Board of Directors approves and reviews all operating procedures and evaluates alternatives. (The Board comprises: Managing Director, Works Director, Technical Director, and Sales Manager.)			
MEASUREMENT	Production Manager and Divisional Manager.			
COMPARISON	Divisional Manager, Works Director and Managing Director.			
DECIDE ACTION	Divisional Manager and Board of Directors.			
TAKE ACTION	Production Manager and Divisional Manager.			

Figure 5.18d: Planning control grid for Wilkie and Paul Plastics
 Production Department, continued.

CONTROL FACTORS CONTROL OPERATIONS	Material costs	Labour costs	Other costs	Floor layout
INFORMATION SOURCES	Weekly and monthly reports produced by Cost Accountant.	Weekly and monthly reports produced by Cost Accountant.	Cost Accountant produces monthly statements.	Work Study Engineers' plans.
SET STANDARD	The Board of Directors approves and reviews all operating procedures and evaluates alternatives. (The Board comprises: Managing Director, Works Director, Technical Director and Sales Director.)			
MEASUREMENT	Production Manager, Divisional Manager, Administration Manager.			Production Manager, Divisional Manager, Industrial Engineer.
COMPARISON	Divisional Manager, Works Director and Managing Director.			
DECIDE ACTION	Divisional Manager and Board of Directors.			
TAKE ACTION	Production Manager and Divisional Manager			Production Manager, Divisional Manager, Industrial Engineer.

PRIMARY DECISION FACTORS →	PRODUCTS	RESOURCES
MEASUREMENT	Technical Manager, Technical Director, Managing Director.	Divisional Manager, Works Director, Development Engineer, Administration Manager.
COMPARISON	Marketing Director, Technical Manager, Technical Director, Managing Director.	Managing Director.
DECIDE ACTION	Board of Directors.	Board of Directors.
TAKE ACTION	Divisional Manager, Production Manager.	Divisional Manager, Production Manager.

Figure 5.19: Primary decision making grid for Wilkie and Paul
Plastics Production Department.

3. DISCUSSION OF THE CASE STUDY FINDINGS

Introduction

The following discussion is based upon the results of the two case studies presented in this Chapter. A third case study (of Wilkie and Paul Tin Box Production Department) is presented in Appendix IV; this third case study has not been included in the present Chapter because the pattern of results is very similar to those of the two studies already described. The same method of analysis was used to study two "co-ownership" enterprises and the results of these case studies are presented in Appendix II. Discussion of the results of these additional case studies accompanies their respective descriptions and is not included in this Chapter.

It is the intention here to discuss the results of the studies of Ferranti's Rotating Components Group and Wilkie and Paul Plastics Production Department in answer to three questions:

1. What is the value of this method as a technique of organisational analysis per se?
2. How can this method be used to generate job and organisational design choices?
3. How can the method be used to calculate the effects of specific job and organisational design changes on other positions and departments in an organisation?

Each of these questions will be discussed in turn.

What is the value of this method as a technique of organisational analysis per se?

This method appears to have a number of potential advantages as a technique of organisational analysis. Any approach to the study of organisational structure and functioning must adopt some conceptual viewpoint, a way of looking at the phenomena in which one is interested. But any particular approach to a problem or group of problems necessarily precludes adopting other potentially fruitful approaches. So in order to begin to overcome any limitations or difficulties of a particular approach or conceptual viewpoint, these limitations and difficulties should be clearly recognised. In discussing this technique of organisational analysis, therefore, an attempt is made to note some of the possible limitations of the technique. The suggested advantages and limitations of the technique are summarised in Figure 5.20.

One advantage of the technique is that it attempts to be comprehensive; the unit of analysis is the organisation as a whole. The first problem that was encountered in carrying out the analysis, however, concerned the magnitude of the task. Even the smallest organisation is capable of displaying considerable complexity when subjected to detailed study. To complete all the stages of this analysis is, therefore, a daunting task. The researcher approaching an organisation must face problems concerning the time that is required to conduct a full and detailed analysis, and concerning any restrictions upon access to information that the organisation may impose. These problems are surmounted where an internal research team can be established, comprising members with substantial experience of the organisation and the way in which it functions.

Figure 5.20: Assessment of the value of this method as a technique of organizational analysis per se.

POTENTIAL ADVANTAGES	POTENTIAL LIMITATIONS
1. Comprehensive.	1. Time consuming to complete.
2. Focuses attention on role of manager as an information processor.	2. Directs attention from other managerial skills.
3. Easy to describe managerial tasks in terms of the model.	3. Gives a fragmented description of the integrated process of control.
4. Model and approach readily appreciated by management at all levels.	4. Directs attention away from other problem areas.
5. Highlights specific control problems: <ul style="list-style-type: none"> ● gaps in control system ● coordination problems ● sources of conflict 	5. Partial analysis may attribute problems and solutions only to areas studied in depth.
6. Analysis illustrates certain characteristics of production control: <ul style="list-style-type: none"> ● number of levels of hierarchy engaged in each level of control ● "escalation" of control information ● relationship between technology and control system? 	6. Limited sample examined here.
7. Other uses of the analysis: <ul style="list-style-type: none"> ● management development ● performance evaluation ● management job analysis 	

The structure and functioning of organisations are complex phenomena, and models used to describe, explain and analyse these phenomena must reflect that complexity. The case studies reported here are thus incomplete. The stages of the analysis concerning co-ordination between operating systems and information exchange with the enterprise's environment were omitted. The descriptions of the routine control operations are relatively complete, but as planning and primary decision making rely upon information concerning the organisation's environment, the descriptions of control at these levels is incomplete. An analysis of co-ordination operations is also missing at both the routine control and planning levels. These case studies present only a partial practical test of the value of the technique.

A second advantage of the technique is that it focuses attention upon the function of management as an information processing and control function, rather than as a "leadership" or "decision making" function. Decision making is only part of the control process and the quality of decisions made will only reflect the effectiveness with which the other control operations are conducted. The technique thus attempts to analyse the management function as a whole, and does not concentrate on any one specific part of it. This approach may, however, direct attention away from other necessary management skills such as scientific/technical or social skills, although even these can be regarded as information processing skills.

A third advantage of the technique lies in the comparative ease with which industrial control operations can in practice be related to the components of the model. After questioning managers about

their jobs, it was not particularly difficult to place the tasks that they perform into the format of the model. An air of artificiality may be introduced to the analysis where one individual performs two or more consecutive control operations, and it could be argued that the analysis describes in a fragmentary manner what is essentially an integrated process of control. Organisational control, however, is apparently carried out in a fragmented manner part of the time, and the method of analysis should be capable of illustrating this.

A fourth advantage of the technique is the instant understanding and appreciation that it receives from management at all levels. The model is couched in terms that managers can readily relate to their own work and problems; applying the technique as a research tool is easier where respondents understand its nature and purpose. Most managers admit to having "communication" or "information" problems of various kinds. Attention paid to these problems, however, may again direct attention away from other perhaps more fundamental organisational problems.

The model upon which the technique is based is a logical statement of an ideal organisational control system, i.e. what components the control system should have if information processing and control in the organisation is to be effective. A fifth advantage of this technique, then, is its ability to highlight control problems in a given control system. In Ferranti's Rotating Components Group, for example, the procedures used for the routine control of order throughput times do not provide adequate information upon which to base planning decisions regarding this factor. Records are kept of actual throughput times but they are not kept in a suitable format. It is a time consuming task, using the existing records,

to calculate the average throughput time of a particular type of product; it is even more difficult to assess the effects of delays with one type of product upon the throughput times of other products. The management in this case were aware that the throughput times for some items were excessive and that this made it difficult to calculate and to meet delivery dates. There was not enough information, however, upon which to base a decision to improve the matter.* A more detailed consideration of the analysis could identify actual and potential problems of co-ordination between operating systems and could indicate potential sources of conflict. But a partial analysis of the type described above may attribute problems and solutions to the areas actually investigated, ignoring the effects of (and possible effects of particular actions upon) other parts of the organisation and other parts of the information processing and control function, that have not been analysed.

The two case studies described in this Chapter (and the third case study described in Appendix IV) appear to illustrate some common characteristics of production control systems. One such characteristic concerns the number of levels of management that are engaged in routine

* A report was submitted to the General Manager, as a result of this research, suggesting that items requiring rectification should be re-routed to separate sections. Items which were produced correctly would continue assembly as normal. Through keeping records of the items which required rectification separate from those concerning straightforward items, it would become possible through time to predict with greater accuracy the throughput time for a particular order. And by taking troublesome items out of the system, normal items could be produced much quicker. Thus some delivery dates would be met earlier and all delivery dates would be more accurate in the long run.

control operations. In the Rotating Components Group, the highest level of management concerned with routine control is the Production Engineer but the Production Manager and Chief Quality Engineer are also involved on occasion. There can, therefore, be up to four levels of management performing the routine control operations, i.e.:

Assembly Chargehand
 Assembly Foreman
 Production Engineer
 Production Manager,

or:

Test Chargehand
 Test Foreman
 Assistant Quality Engineer
 Chief Quality Engineer

This does not include intermediary levels such as Senior Foreman, Planning Engineer, or Engineer I/C Control. The same is true for Wilkie and Paul where again up to four levels of management may be engaged in routine control, i.e.:

Chargehand
 Supervisor
 Production Manager
 Divisional Manager

A given routine control problem will not necessarily concern all four levels every time that it arises. A second characteristic of production control that these case studies illustrate concerns what may be called "escalation" of routine control problems. This research was not directly concerned with why particular routine control problems were passed up the hierarchy to be dealt with, but only how such problems were handled. Speculation as to why this occurs is, however, still possible. It is extremely rare to find one person performing all the routine control operations for any control factor. Routine control of task allocation within production sections appears to be one exception. In Wilkie and Paul,

the Extrusion Supervisor has full routine control over the distribution of tasks within the sections for which he is responsible. It is far more common to find routine control operations being performed by a succession of personnel, each at a higher level than the last person involved. The simpler problems are likely to be dealt with by the person who first detects them, the first line supervisor perhaps. But a number of problems are passed on up the hierarchy before a decision is made by the Production Engineer (Ferranti) or Production Manager (Wilkie and Paul). The process of "escalation" may be due to at least three reasons:

1. The people who pass information about routine control problems to their superiors are actually not competent to deal with the problem raised.
2. The people who pass information about routine control problems to their superiors assume that they themselves are not competent to deal with the problem.
3. The people who pass information about routine control problems to their superiors assume that this is a problem that the superior should be made aware of.

Each level must, therefore, assess the consequences of not transmitting such information to a superior. Where the information is not transmitted, the subordinate is committed to providing his own solution or to doing nothing about it. The subordinate may thus place himself in line for a reprimand if he takes the wrong decision, or if the matter gets considerably worse for some other reason and the superior asks why he was not informed in the first place. It may, therefore, be safer to transmit routine control information to the superior rather than attempt to solve the problem as it is detected.

There appears to be some flexibility regarding decision making at the routine control level that is not present in either the planning or primary decision making levels. In the latter cases, decision making is virtually confined to the top two or three levels of management (in the companies studied), but routine control decision making may be carried out on a number of levels by a number of different personnel. One problem confronting the job designer, therefore, may lie in "de-escalating" routine control decision making, rather than "de-verticalisation" as Wild (1975) has suggested. The existence of a hierarchy of management of any kind at this level may presuppose its usage in the operations of routine control.

While these conclusions refer to the case studies described here, these obviously represent a rather limited sample of types of production control system. It would be inadvisable, therefore, to generalise from these findings with regard, for example, to the exact number of hierarchical levels engaged in a particular level of control. The technique of analysis could, however, be used to advantage in comparing different types of control system, and perhaps to compare the effects of different types of technology on patterns of control. (See Woodward (Ed.), 1970a.)

A final advantage of this technique of organisational analysis is that it may be used for more conventional personnel management purposes. The analysis could be used as a basis for a management development programme, for moving managers from positions concerned with routine control into positions concerned with measurement and comparison of routine control information for planning purposes, and then into positions where planning decisions are taken, and so on. The analysis could also be used to design performance evaluation

systems; the model assists in the identification of suitable performance measures for specific positions in the organisation, and can also be used to derive appropriate means of measuring and recording performance indicators and for arranging appropriate feedback of results to the positions concerned. Finally, the analysis can be used as a basis for managerial job analysis. It is the simplest of matters to go through, for example, the routine control grid for the Rotating Components Group and identify all the control operations performed by the Production Engineer. Job analysis has a number of uses, but is clearly relevant to the design of jobs. The original objective of this technique was to produce an analysis of the management function in an organisation that could be used to redesign the jobs of lower level workers. To the extent that the management job analyses that the technique produces are valid, this objective has been fulfilled.

How can this method be used to generate job and organisational design choices?

The routine control, planning and primary decision making grids for the two production systems analysed above list all the management tasks concerned with the basic hierarchy of control of those production systems. The tasks involved in co-ordination between operating systems and in information exchange with the environment, are not included. If these analyses were to be used as a basis for job and organisational design, the first question that would be dealt with would be: which management tasks can be transferred to operators? The objectives of this project would include at least some of the "desirable job characteristics" listed in Figure 2.8 above. At

least four of the major objectives listed there could be achieved by reallocating or reorganising the production operations themselves: variety, task identity, use of valued skills and abilities, and group membership. Fulfilling these objectives would not necessarily involve the transfer of management tasks to operators. The transfer of management tasks to operators becomes necessary in order to provide operators with the following job characteristics: responsibility, autonomy, continuous learning and growth in competence, advancement, and perhaps feedback also. These latter job characteristics require reallocation of management tasks to operators and are more likely to provide satisfaction of higher order needs such as autonomy, competence and self-actualisation.

There appears to be little scope in either of the companies studied for the introduction of job and organisational design changes. This does not, however, preclude the gradual introduction of changes in the direction desired. The ideal or optimum job design solution could be regarded as the establishment of composite autonomous groups of operators who carry out all the physical and routine control operations within their operating system. To reach this solution in either the Rotating Components Group or Wilkie and Paul would take a very long time, even if the managements of these respective companies considered that this was a worthwhile undertaking. But a gradual move in this direction is possible. This could be achieved in the following way; the suggested process is summarised in Figure 5.21.

The first stage would be to identify control factors which at the routine control level are measured and controlled within the operating system concerned, and which have the routine control operations carried out by comparatively few hierarchical levels. In the Rotating

Figure 5.21: The gradual introduction of job and organizational design change.

1. Identify control factors where routine control operations are carried out within the first three levels of supervision, and which are measured within the operating system concerned.
2. Arrange feedback of performance results concerning those factors to be given directly to the operators concerned.
3. Involve operators in the measurement, comparison and decide action operations for these control factors, but maintain supervision; supervisor may in fact make most of the decisions.
4. Gradually withdraw supervisory assistance as operators gain capability and confidence to take decisions themselves.
5. Identify other control factors that operators could control and repeat the above process.
6. Eventually allow operators to perform all the routine control operations for that operating system.
7. Repeat this process at the planning level.
8. Re-assess and redesign the jobs of (typically) first and second line supervision (become "coordinators").

Components Group and Wilkie and Paul, the following control factors meet these criteria, and are controlled by no more than three levels of supervision at the routine control level:

Rotating Components Group :

assembly:	task distribution within sections, task distribution between sections, product quality.
test and inspection:	task distribution within sections, throughput time.

Wilkie and Paul :

extrusion:	product quality, task distribution within sections, task distribution between sections.
forming:	task distribution within sections, task distribution between sections.

The second stage would be to provide operators with some form of feedback that would indicate the results of different actions upon performance concerning those control factors. Some suggestions for providing feedback on the selected control factors are indicated in Figure 5.22. The operators in these two production systems are not involved in the routine control measurement and comparison operations, and the third stage in the job design process would be to allow them to perform these operations with supervisory assistance. Supervisors could also allow operators to participate in taking decisions concerning these control factors, even if the supervisors actually take most of the decisions. The ways in which this stage would affect the operators concerned are described in Figure 5.23.

The fourth stage of this process would consist of a gradual

Figure 5.22: Suggestions for providing feedback on selected control factors.

Rotating Components Group

SECTION	CONTROL FACTOR	FEEDBACK FOR OPERATORS
assembly	task distribution within sections task distribution between sections	weekly reports showing scheduled workload of each section for last week, manning levels and actual output and quality levels achieved.
	product quality	reject items returned to operator responsible as soon as possible with report indicating reasons for rejection.
test and inspection	throughput times	weekly reports showing average throughput times for each product type, and changes in throughput times over last 6 months or year.

Wilkie and Paul Plastics

SECTION	CONTROL FACTOR	FEEDBACK FOR OPERATORS
extrusion	product quality	operator performs and permanently records results of all quality checks; these can be analysed to indicate recurring problems.
	task distribution within sections task distribution between sections	weekly reports showing scheduled workload of each machine for last week, manning levels and actual output and quality levels achieved.
forming	task distribution within sections task distribution between sections	weekly reports similar to those for the extrusion section.

Rotating Components Group

SECTION	CONTROL FACTOR	OPERATORS PERFORMING CONTROL OPERATIONS
assembly	task distribution within sections	operators decide when a change in existing task distribution may be necessary or desirable; supervisor will check and confirm the new arrangements; operators record new task distribution and this record is used to compile the weekly report. (the supervisor will compile this report - see Figure 5.22 for contents).
	task distribution between sections	
	product quality	to allow assembly operators to inspect and test own products would require major alteration to the floor layout, and would also involve retraining operators permanently employed on test and inspection work, perhaps as assembly operators; if this proved to be impossible, operators could at least decide on the necessary repair action to take for each reject with some assistance from supervisor.
test and inspection	throughput times	operators record the throughput time of each order; these times could then be averaged over past weeks or months for each product type; operators and supervisors decide when action is necessary to improve throughput times, and what can in fact be done to achieve this.

Wilkie and Paul Plastics

SECTION	CONTROL FACTOR	OPERATORS PERFORMING CONTROL OPERATIONS
extrusion	product quality	operators perform and record all quality checks and decide with the supervisor on what action to take concerning sub-standard rolls.
	task distributions	same as for Rotating Components Group.
forming	task distributions	same as for Rotating Components Group.

Figure 5.23: Effect of allowing operators to perform routine control operations with supervisory assistance.

withdrawal of supervisory assistance as operators develop the capability and confidence to perform all the routine control operations, including decision making, by themselves. This gradual withdrawal could extend over a considerable period of time. The success of the process would be dependent upon the attitudes and abilities of both the operators and supervisors concerned.

The fifth stage of this process would be to extend the operators' jobs to cover other control factors, perhaps those that are closely related to those that they already control. Operators in the assembly sections of the Rotating Components Group could become involved in the routine control of throughput times, output, scrap quantities and perhaps floor layout. Operators in the test and inspection sections could be allowed to participate in the routine control of task distribution and floor layout. In Wilkie and Paul Plastics, operators in the extrusion sections could begin to participate in the routine control of output, throughput times and scrap quantities. Operators in the forming sections could also participate in the routine control of output, throughput times and scrap quantities, and could gradually be given more opportunity to make decisions regarding product quality. Again, in transferring control of these factors to operators, new methods of supplying operators with appropriate information concerning performance results would be required. Transferring control of these factors would affect still higher levels of the organisation hierarchy, and the time that would be required to complete the process might be considerable.

The first major objective of this process would be to allow the operators to carry out all the routine control operations for that operating system. The second major objective would be to consider

repeating the process just described with the control operations at the planning level. It was suggested in Chapter 4 above that provision of continuous learning as a job design objective would mean allowing operators to decide how to carry out the production (operating) tasks and how to carry out the routine control operations. Operators would thus perform the planning control operations as well as the routine control operations. It is most unlikely that this would ever occur in either of the two companies studied here, but this arrangement does work in one of the co-ownership companies that was studied (Rowen Oullwyn; see Appendix I). If this type of change did become possible and desirable in a conventional company, it could be introduced gradually using the same process used to transfer the routine control operations to the operators. (See Figure 5.21.)

The transfer of both the routine control and planning control operations to operators may not always be possible. It may only be possible where certain basic conditions can be established:

- (a) Where the company as a whole is small enough to permit all its employees to participate directly in planning decisions; or
- (b) Where the company is composed of semi-autonomous operating systems each of which is small enough to permit all its members to participate directly in planning decisions; or
- (c) Where the organisation is being designed from scratch, thus overcoming many of the problems created in attempting to change conventional working methods in an existing company.

And where the company is small enough to allow all of its members to participate directly in planning decisions, it would not be

a great step from there to participation in primary decision making as well. (This also happens at Rowen Onllwyn, which has only 11 employees; see Appendix I.) At this point, the "organisation" does not require to be designed, what does have to be designed is a system of recording appropriate information in a format that can be used by the members of the enterprise as a basis for collective information processing and control. Organisational design (i.e. defining positions, roles, role relationships, line and staff functions, and so on) is replaced by the necessity for information system design.

The final stage of this gradual process of job and organisational design change concerns the re-assessment and redesign of the jobs of higher organisational levels that are affected by the transfer of control operations to operators. But this is listed as the last stage of the process simply for convenience. This re-assessment should be conducted throughout the change process. The following section indicates how the effects of transferring control operations alter the jobs at higher levels in the organisation.

How can the method be used to calculate the effects of specific job and organisational design changes on other positions and departments in the organisation?

The two case studies examined above illustrate quite clearly that "vertical" job design changes for operators are likely to affect not only first line supervisors but a number of levels and positions in the organisation hierarchy. Contrary to the opinions of most writers in this field, therefore, this problem is not confined to the

changing role of the first line supervisor. This may be the position most severely affected, but where job design changes are extensive, the impact on second and third level supervision may also be extensive. It has already been indicated that in the two companies studied there were typically four levels of management dealing with the routine control of the production system.

The technique of organisational analysis used here, therefore, allows the job or organisational designer to calculate with precision the effects of specific design changes upon the rest of the organisation. The roles of first and second line supervision may become completely redundant where routine control operations have been completely transferred to operators. The tasks that remain, at routine control level, are those concerned with co-ordination. First and second line supervisors are likely, therefore, to become "co-ordinators". It would be necessary to carry out a full organisational analysis (rather than the partial analysis described here) in order to explore in detail the potential role of the traditional supervisor as a co-ordinator.

Summary of Case Study Findings

It has been suggested here that the ten step method of organisational analysis, presented first in Chapter 4 above, has a number of advantages as a basis for job and organisational design, and in more conventional personnel management areas. The analysis can be used to identify potential job and organisational design changes and can also be used to calculate the effects of these changes upon other positions in the organisation. An examination of existing job design techniques (see Figure 2.7, above) shows that

they rely on more or less ad hoc methods for producing job and organisational design changes. The method of organisational analysis described here provides a means of systematically examining the entire range of options open to the job or organisational designer. It is also an advantage to be able to calculate, using this method, the effects of given changes on other jobs in the organisation.

The model indicates potential "ideal" solutions, i.e. "ideal" job or organisational designs. It has not been argued here that these ideal solutions be imposed upon new or existing enterprises. These are rather the long term objectives towards which job and organisational design should be steered, and a number of suggestions as to how this steering can be gradually moved in the right direction have been provided.

The relationship between the types of job and organisational design changes suggested here and job design objectives is comparatively straightforward. Allowing operators to perform routine control operations is clearly giving operators more responsibility. Giving operators control over more control factors is one way of increasing responsibility. Giving operators the planning control operations to perform is also an increase in responsibility. Autonomy is increased by withdrawing supervisory assistance. Autonomy can, therefore, be measured by identifying which control operations are still performed partly or wholly by supervisors. Operators may be autonomous in that they have complete routine control over one control factor (e.g. task distributions); they may be autonomous in performing all the routine control operations for their operating system; they may be autonomous in performing all the planning control operations for their operating system; and

there is a multitude of intermediary stages between these basic points. Growth in competence is obviously encouraged by expecting operators to take over larger portions of the management function. When this type of change is introduced gradually, it can generate a sense of advancement in those affected.

The technique of organisational analysis presented here and the model upon which it is based solves to a large extent the problem of making job design objectives operational, that is of producing suggestions as to how specific jobs can be given more "responsibility" or "autonomy" and so on. The general model of organisational control used here makes this a fairly simple task.