Macmillan Handbooks in Industrial Management

Alan Lawlor

Works Organisation

Introduction to the Series

The eight books comprising the 'Macmillan Handbooks in Industrial Management' series were from the outset planned as an entity, and together they cover comprehensively yet concisely the varied aspects of knowledge required by those who manage a modern factory or plant. At the same time, care has been taken to ensure that each volume shall be complete in itself, and carry sufficient basic management theory for a proper understanding of its specific subject.

By this means, it has been possible to avoid a common pitfall in the path of many writers on management subjects, namely an attempt to cover all possible ground in one major volume, with varying degrees of success.

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It is expected that many practising works managers and mature students will wish to have the whole set on their shelves, but that others will welcome the opportunity of buying single volumes to meet their particular needs.

Thanks are due to the authors for the enthusiasm with which they have joined in the enterprise, and to members of the staff of the Institution of Works Managers for practical support on many occasions.

J. Ekins

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Works Organisation

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Foreword

In the world of modern industry, it becomes increasingly necessary for managers to be aware not only of the fundamental principles of good management, but also of the latest techniques necessary for putting those principles into practice.

Works managers in particular, because of the salient position which they hold in the management structure of modern industry and their responsibility for translating policy into execution, must be both educated in sound theory and trained in modern methods.

This series of eight books has been designed to provide the basis of that education and to supplement essential experience.

I welcome the opportunity the Institution of Works Managers has been given to sponsor this venture and commend the books to all present and future managers in industry.

RICHARD MARSH

Chairman, British Rail

President, Institution of Works Managers

Acknowledgements

The writing of any book must inevitably involve self-discipline and organisation, but above all else it is a task that relies on the support and assistance of many people.

My thanks, therefore, go to Jim Ekins, who was instrumental in getting me started, to Tony Pirie for his gentle prodding, and to both of them for their skilful editing. My appreciation also goes to my publisher, without whose efforts this series would not have appeared.

I am indebted to the companies who co-operated in my works organisation investigation and to the many companies who have unknowingly helped me. In addition, my appreciation goes to the writers of the many works quoted as references.

Finally, my thanks go to Jill Sealey for her patience in translating my scribble into the typed draft and to my wife, Nancy, also for her typing assistance and especially for her patience.

A. L.

1 | Introduction

WHY STUDY WORKS ORGANISATIONS?

Most managers will probably agree on the need to study the way we organise work if it leads to more productive operation and a more satisfied work-force. On the other hand, the notion that easy cook-book-type answers will be forthcoming must be immediately dismissed. There is also a growing realisation that the problems facing individual companies are unique, certainly unstructured, and furthermore only solvable by the managers involved taking a hard and analytical look at each situation as it arises. This is not to suggest that theoretical knowledge is not important; it is, but it needs to be applied as problems arise and not as some universal prescription. This is not to imply that there is no need for forward thinking; indeed, a fast-changing society requires management to plan now for the kind of organisation it will need in the next three to five years, always realising that at the end of the period the whole thing will probably require changing again. Such changes could involve the manufacturing organisation in new layouts, modified control systems, alteration in the pay structure and – a matter of great significance – some change in everyone's job. If companies are to survive and provide a combination of economic viability and job satisfaction, then their managers must be very much concerned with determining if the existing set-up is fitted for the tasks ahead of it.

DEFINING THE WORKS ORGANISATION

An organisation means different things to various people. In some cases it means the kind of paper used, to others the various departments and, on a more cynical note, the passing of information in the washroom or along the grapevine. Clearly it is all of these things, and more. A study of the works set-up requires attention to the technical areas which include, among other things, the arrangement of plant and the way the work flows through the system (more about this later and in Chapter 2). The number and kind of departments, and who is responsible for what, is also an essential aspect. Two kinds of organisation are evident in this analysis. One is the formal organisation chart which sometimes hangs on the wall in the works manager's office; the other, perhaps the more important, reflects what actually goes on in practice and is sometimes called the informal organisation. Some relevant theoretical knowledge may be helpful here. In Wilfred Brown's book *Exploration in Management* (1965) he presents four kinds of organisation:

1. **Manifest.** The situation as formally described and displayed. This would include organisation charts, job descriptions and operation layouts.
2. **Assumed.** The situation as it is assumed to be by the individual concerned. The manifest and assumed situations conflict with each other. It is therefore probable that if there are 300 people in a company there could be 300 different assumed organisations.
3. **Extant.** The situation as revealed by systematic exploration and analysis. Sometimes compared to the informal organisation as representing what really goes on. Despite all the available methods of analysis, the extant or living situation may never be completely revealed.
4. **Requisite.** The situation as it would have to be to accord with the total properties of the field in which it exists. This analysis accords with previous comments about developing an organisation to suit the environment in which it finds itself. This is what another writer, Professor Tom Lupton (1971), has described as finding the best fit! It is also worth noting that the principal aim of 'management by objectives' is to determine the requisite organisation.

This shows that an organisation is that situation where a group of people, together with physical resources, combine to achieve certain objectives. There may, of course, be conflict on what they should be, and how they might be achieved. Yet everyone – management and unions alike – is concerned with the undenied objective of staying in business. At the works level, the definition might be stated as that arrangement of human and physical resources which best satisfies overall output requirements consistent with as low a cost as possible. A number of other objectives that concern the works manager will be considered in more depth in Chapter 2. What must be said at this stage is that commitment to the achievement of objectives is all-important for all levels of the organisation.

THE ENVIRONMENT

As mentioned earlier, any company to be effective needs to adapt to the external situation in which it is operating. What happened to the dinosaur because it could not adjust is ancient history; more recently, BSA, Upper Clyde Shipbuilders and Volkswagen exemplify failed adjustment. While marketing is considered by some to be outside the province of the works, this function's effects certainly influence shop-floor operations. Indeed, no matter how good the production control system, there will still be chaos if the available manufacturing capacity does not match the market requirement. Encouragingly, numbers of companies are now examining their existing set-ups to see in which ways they need altering.

Some internal factors likely to be affected by a changed external situation include the kind of plant and its arrangement, quality standards, delivery performance, cost control and related pay systems. The response to a new set of circumstances should be decided on whether a 'bush-fire' approach or forward thinking is appropriate. The former policy waits for changes to occur and then does something about them; the latter seeks out problem areas before they cause trouble. A forward-thinking policy can give more problems than already exist, but in this fast-moving world this is perhaps the only way to survive. This admittedly raises the controversial area of forecasting, nevertheless, with all its shortcomings the race will go to those there with the right set-up at the right time.

KINDS OF ORGANISATION

As already mentioned, there are no cookbook answers to a company's problems. Therefore, while it is useful to examine differences in organisations, what applies in one case will not necessarily apply in another. Nevertheless, a comparative study may well reveal, amongst other things, some of the essential characteristics which can be used not only for measuring performance but also for determining those factors which influence the form of organisation. Obvious things that make one company different from another are the number of employees, factory area, total assets employed and sales turnover. These are, of course, all different ways of measuring size. Research studies seem to indicate that the two basic things with the greatest influence on organisational characteristics are the product and the quantity made at one time. We shall now take a brief look at some of the ways these can affect the factory:

Product: materials handling, size of factory, predictability of production process, quality emphasis and working conditions.
Quantity to be made: factory layout, amount of production engineering, cost emphasis, span of control of supervision, industrial relations climate and job satisfaction.

The basic types of factory organisation which emerge as a result of these two influences are:

1. Jobbing or very small-quantity production.
2. Batch production.
3. Mass or flow production.
4. Process or continuous production.

The late Joan Woodward's study (1958) into the characteristics of industrial organisations divides them into unit, mass and process technologies. This study showed that the factors which seem to vary from one technology to another are:

1. The number of levels of authority.
2. The span of control of supervision.
3. The ratio of managers and supervisors to total personnel.
4. Proportion of labour costs to total costs.
5. The ratio of direct to indirect labour.
6. The amount of written as compared with verbal communication.
7. The number of specialised management functions, such as production control, organisation and methods, safety and personnel.

Research studies of this kind are useful because they provide an insight into the problem areas.

PROBLEM AREAS

While a detailed look at what makes an organisation tick might be interesting, it has more value if we uncover and solve the various problems facing it. Everyone involved in the production management 'arena' knows that you learn to live with the problems. Although this is true, an objective study of the situation can make life both more orderly and more profitable. Below are outlined some of the more important matters of concern affecting the works organisation.

People
Wages are rising faster than output – a situation sometimes called productivity drift – through disputes and a lack of commitment to company objectives. Of course, problems with people are bound to involve works managers in the areas of industrial and human relations which are outside the scope of this book. Nevertheless, they exert a significant influence on the works organisation.

Quality
Scrap and rejects are rising although more cost has been incurred by quality control. This may be due to inadequate quality standards or a failure to understand, and deal with, the conflicting nature of failure and prevention costs.

Maintenance
Increasing mechanisation makes breakdowns more significant. On the other hand, somewhat similarly to quality control, it is uneconomical to spend more on preventing breakdowns than the cost of down-time: hence the need for analysis before taking action.

Production

1. Overdue orders.
2. Too much inventory.
3. Failure to meet delivery dates.
4. Shortages of materials and parts.
5. Operations additional to those on the planning sheets.
6. Urgent requests for jobs that have already been completed.
7. Conflicting requests for jobs at the workshop level.
8. Orders are being completed that are not required.

9. Part-finished assemblies awaiting parts not yet received from suppliers.
10. New production control systems, new plant and improved methods apparently failing to achieve any increased productivity.

These are just a few of the problems which most works managers have come across. There are others, of course, and problem identification will be receiving more attention throughout this book. For the time being, it is worth restating the need for concern not only with immediate problems. Problems should be anticipated and, therefore, sought out.

THE WORKS ORGANISATION

Whatever the size of the company, certain basic functions are common to most firms. This is also true of other related activities. Those functions which must be carried out, in companies both small and large, will most probably include:

1. **Accounts.** Even if sophisticated costing techniques cannot be justified, some account of sales and purchases must be kept.
2. **Design.** Even if done on the back of an envelope, some design or technical activity will be found in every company.
3. **Personnel and wages.** Generally in the smaller company personnel records and wages are one function and are quite often the responsibility of the accounts man. This activity will also include a responsibility for the company's legal obligation or what is sometimes called the secretarial function.
4. **Sales.** Peter Drucker, that prolific writer on management, says that the real boss of every company is the customer. Therefore, sales is a most important activity in every firm, even if as in smaller concerns it becomes merged with other functions.
5. **Manufacturing.** This book's prime concern, but an effective works organisation needs to be integrated with the previously mentioned functions.

This brief look at the five basic company functions leads to examining the principal task which concerns the works. At this stage, it may be assumed that the factory exists and that rightly or wrongly the decision has already been made on the kind of plant and its arrangement. On these premises, the main tasks are as follows:

1. Programming orders including delivery promises.
2. Determining manufacturing methods.
3. Providing estimates of production costs.
4. Authorising the purchase of materials and parts.
5. Authorising the manufacture of tools and equipment.
6. Receiving and storing parts and materials in the most effective manner.
7. Effective and economical maintenance to keep down-time to a minimum.
8. Controlling expenditure through some kind of budgetary control.
9. Controlling technical standards through the use of inspection and quality control.
10. Controlling production flow by the use of effective progress.

Another way of looking at organisations somewhat resembles the analysis of decision-making. There is firstly the rational systematic analysis of what could be done. Secondly, there is the more emotional area of actually doing it. In organisational jargon this equates firstly to the functional or advisory aspects and lastly to the line or executive activities. Work study and production control are functional departments there to give advice, whereas the production manager and his supervisors are there to implement their advice. At least, this is what the theory suggests; in practice the situation is complicated by personalities, lack of role clarity and other factors.

In this brief examination of the works organisation it is perhaps pertinent to mention the need for objectives and job descriptions. Some people believe that job descriptions restrain the good performer. Nevertheless, unless an employee is clear on what is expected of him and what he is accountable for, there is a good chance that he will be frustrated, and in conflict with other job holders, not to mention not knowing where he is going. Indeed, perhaps one of a job description's important benefits, if produced participatively by boss and subordinate, is that it reveals personal and organisational difficulties. For the same reason the organisation chart can be useful, not forgetting Wilfred Brown's four kinds of organisation referred to

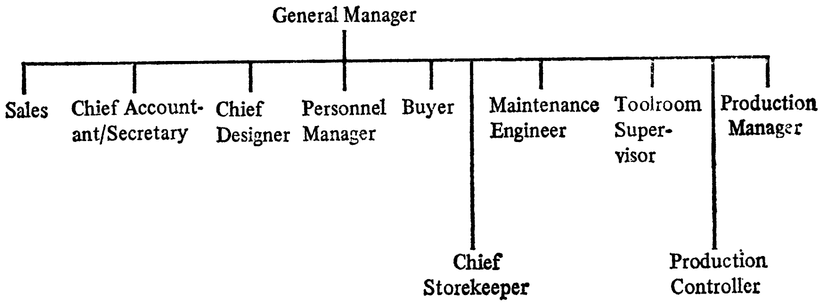

FIG. 1.1. Organisation chart (illustrating a span of control problem)

earlier. As an example, the chart shown in Fig. 1.1 illustrates a general manager who probably has too big a span of control.

WORKS MANAGEMENT SYSTEMS

Much has been written in recent years about the systems approach to organisations. Although the sceptics hold that systems analysis is merely older techniques such as organisation and methods under a new name, nevertheless this kind of approach, however designated, can be useful in revealing weaknesses. Those who have installed computers will agree that a general improvement in the use of paper and the flow of information have been hidden benefits additional to what the computer does. Some of the questions which the systems approach would require an answer to are:

1. The amount and value of inventory.
2. The total cycle time for work to pass through the complete manufacturing system. This time should be compared with accumulated operation times. For example, the latter time for an average batch of work may be, say, 2 days while the former is 30 days. The difference of 28 days is due to such factors as awaiting the machine, unplanned operations and so on. The ratio of one to the other will be called the stagnation factor. In this example, it is $\frac{2}{30}$ or 1:15, i.e. production takes 15 times longer than the theoretical minimum.
3. The kind and arrangement of plant.
4. Who, where and on what basis are important production decisions made? This includes such things as delivery promises,

tools and material promises, purchases, and deciding priorities at each processing stage. These are sometimes regarded as routine, and seemingly unimportant, but they are basic because they are decisions committing the company and its resources.

In Chapters 2 and 3 more attention will be devoted to the factors influencing production flow.

SERVICE, PLANNING AND CONTROL

As already mentioned, a company will include activities concerned with giving a specialist advice and those who have to use it. This kind of analysis implies the need for the works to receive services to keep

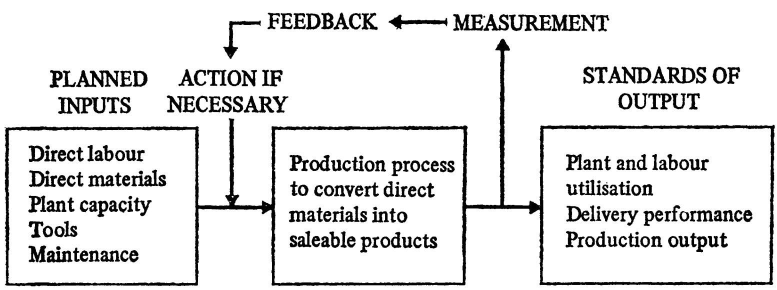

FIG. 1.2. Planning and control in the works organisation

it operational. Probably the two most important service functions are tools and maintenance, to put to rights the wear and tear caused by the production process. Equally important is to be reasonably sure that the service is available when wanted, which of course requires attention to planning, and not only to tools and maintenance. Clearly production, materials and manufacturing capacity also necessitate advance thought. An important prerequisite, then, for an effective works organisation is a plan combined with pre-agreed standards of performance. The last link in this chain is control or, in systems language, feedback. Using a systems approach diagram, the whole thing might appear as shown in Fig. 1.2.

For future reference, the usual activities concerned with service, planning and control are:

1. Maintenance.
2. Operation planning and methods study.

3. Tool design and manufacturing.
4. Work measurement.
5. Work programming.
6. Purchasing and stock control.
7. Progress.
8. Labour and material control.
9. Quality standards.

HOW EFFECTIVE ARE WE?

Whichever way organisations are looked at, the argument is bound to revolve around efficiency, productivity, profit and so on. Good layouts, sophisticated production control and training in human relations are all excellent but meaningless if the company is not efficient. So how is efficiency measured? It might be as well here to differentiate between effectiveness, efficiency and productivity, terms often used synonymously. Productivity is probably best explained as how efficiently the company is producing its particular output compared with the input – that is, how much has been paid for it.

For example, suppose a particular machine in one week achieves an output of 100 units per hour at a labour input of £1 per hour. If in the next week output grows to 108 per hour the output improvement is +8 per cent, but suppose the wages paid are now £1·20 or an increase of 12 per cent, the productivity is then (108/112) × 100 or 90 per cent. Productivity may thus be defined as how efficiently the organisation, or various parts of it, convert inputs into useful outputs. Going further and comparing efficiencies achieved with targets or perhaps with what competitors are doing involves measures of effectiveness. This concept of effectiveness is significant from the point of view of comparing, say, what was achieved under the old and under the new organisation.

There are many other ways of answering the question 'How effective?' Some answers will be considered in Chapter 3. For the time being, these few will be worth thinking about:

1. **Ouput per employee,** that is, total sales turnover divided by total employees. In a Royal Society lecture delivered in April 1968, Dr F. E. Jones quoted average figures in the electronics industry of £1,300 in the U.K. and £5,000 in the U.S.A.
2. **Plant and labour utilisation** is an area of particular concern for

the production man. The figures produced by R. G. Norman in the April 1971 issue of *Works Management* show average productive utilisation of machines and men as 41 per cent and 48 per cent respectively. These figures do not tell the whole story; nevertheless they do suggest the need for attention.

3. **Delivery performance,** which takes a lot, perhaps too much, of production management personnel's time, is a factor which probably does not receive enough attention – at least as far as measurement is concerned. One form of measurement is to compare the planned delivery date with the actual delivery date. For example, suppose a given time of 12 days has taken 18. In this case the ratio is 1·5, so the ideal would be 1·0 with less than 1 being better than expected and anything over, undesirable.

EDUCATION, TRAINING AND ORGANISATIONAL DEVELOPMENT

As already shown, the study of the works organisation requires understanding of how a changing external situation affects the internal system. At the same time, measurements of performance are required to tell us how we are doing. All this suggests the necessity to prepare individuals in the organisation for change and to provide managers with the necessary tools for analysing and developing more effective organisations. The educational process, which should help, is perhaps concerned with the following two broad areas:

Economic and Technical Analysis	**The Environment**
Managerial economics	The nature of change
Statistical methods	Practical social science
Finance and costs	The nature of conflict
Work study	Industrial relations
Quality	Personnel statistics
Maintenance	Interviewing
Production flow	Group problem-solving
Problem-solving and decision-making	

As far as practicable, these subjects should be so integrated that the manager is able to contribute to the development of himself and the organisation of which he is part. It is this area of application which is really concerned with training. There are no universal answers to management's problems, so the objective of training and education should be to enable the various managers to develop the organisation to suit its particular situation. The basic steps that might be taken to design a more effective works organisation can be listed thus:

1. What are the nature and size of changes that have taken place and are likely to occur?
2. Obtain the basic measurement of existing efficiency and how much and what kind of improvement would be desirable.
3. What are the main characteristics of the existing set-up?
4. In the light of 1–3 above, what alternative changes are open and what are their likely economic, technical and social implications?

SUMMARY

The objective of this opening chapter has been to set the scene for a more detailed examination of the works organisation. An attempt has been made to show that no firm can afford to stand still, that there are no easy answers and that a careful and analytical look at the situation is the important requirement. Nevertheless, there is a good deal of written work which can be used to assist in the task, but again, such work must be applied practically to suit the circumstances. Lastly, adapting and changing organisations is a continuing process; it is not a once-and-for-all exercise. For this reason, the end of each chapter will include a reading list and practical tasks which may help you to relate everything said to your own situation.

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CHECK THE CHARACTERISTICS OF YOUR COMPANY

List the changes that have taken place in the following aspects of your company over the last two years:

(*a*) Total employees.
(*b*) Total works employees.
(*c*) How many new products have been introduced?
(*d*) How many new departments of functions have been created?
(*e*) How many totally new processes have been introduced?
(*f*) What new changes do you forecast for the next five years?
(*g*) What business are you in?

Read Bertram White's little book before answering the above question.

(*h*) What is your basic production method: jobbing, batch, mass or process?
(*j*) Have a go at measuring your 'stagnation factor'.
(*k*) What are your current measurements of:
  Output per employee
  Average plant utilisation
  Average direct labour performance
  Average delivery performance.
If you honestly do not measure these, put NO.

2 | The Works Organisation

THE NATURE OF WORKS ORGANISATIONS

Any organisation, but particularly a manufacturing organisation, has as its principal aim the profitable conversion of materials or inputs into saleable products or services. The nature of this conversion process or how it is organised requires examination. After all, while other parts of the business, such as marketing, design and accounts, are clearly important, it is when materials are being converted in some way that profit should be being made. Furthermore, this profit's size and rate depends very much upon the effectiveness of the works organisation. What causes one set-up to be better than another probably depends upon the right interaction between economic, technical and social forces – not forgetting the old foe change and how we respond to it. Some aspects of these three forces will receive fuller treatment in the other books in this series. For reference, all the more important subject areas, which will be touched on, are listed below under the main headings:

Economic

1. Cost standards for materials, labour and plant.
2. Budgets for departmental expenditure.
3. Inventory control.
4. The efficiency of the conversion process.
5. Delivery performances.
6. Wage-payment systems.
7. Control systems.

Technical

1. Type of buildings and manufacturing facilities.
2. Arrangement of manufacturing facilities.

3. Production method, i.e. jobbing, batch, mass or process.
4. Manufacturing services, i.e. production planning and control, tooling, maintenance, inspection, materials movement, receiving stores and dispatch.
5. Technical standards.

Social

1. Organisation structure.
2. Works objectives.
3. Job descriptions.
4. Personnel policies.
5. Industrial relations.
6. Safety policies.
7. Absenteeism and labour turnover.
8. Effectiveness with which the human resources are being used.

Fig. 2.1 shows in diagrammatic form the economic, technical and social characteristics of the works organisation now described. It will be seen that the difference between productive materials and sales revenue is shown as total earnings. This is an engineering concept developed by Professor Harold Martin (1964). This idea occurs again in Chapter 7; for the moment, it may be stated that a fundamental objective of the conversion process is to increase total earnings. It is also worth noting that at the national level total earnings is equivalent to gross national product, and furthermore a modification of total earnings forms the basis for the calculation of value-added tax.

ORGANISATIONAL SIZE

The size of an organisation not only directly affects its performance but is also valuable for comparison purposes. Size can be measured in a number of ways, such as total employees, floor area, sales turnover and capital employed. Not that bigness necessarily implies large profits; indeed, an article by C. Pratten in *Management Today* (1967) demonstrates this point. Size statistics in whatever form can perhaps serve two useful purposes:

1. When compared with other companies they show how effective we are as related to our own internal measurements of efficiency – the two terms contrasted in Chapter 1.

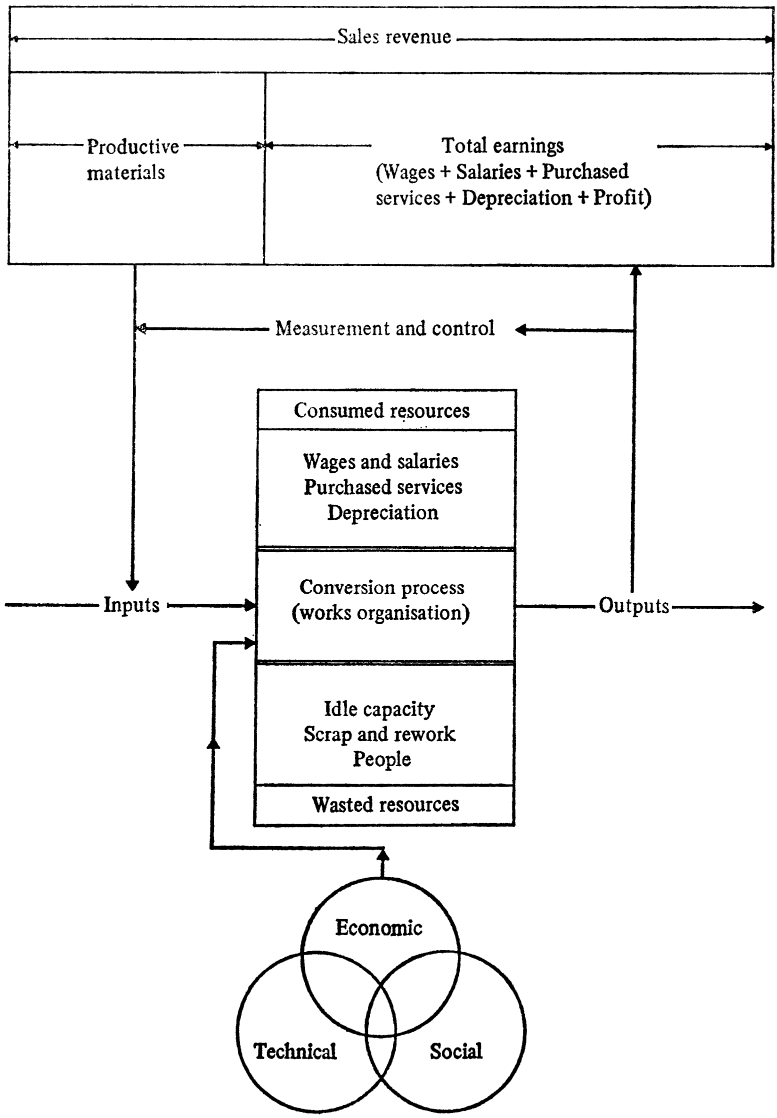

FIG. 2.1. The nature of the manufacturing process

2. They show how we stand in the industry, for instance in regard to the amount of concentration. That is, is a significant proportion of total output in the hands of two or three large firms? Furthermore, if you are a small firm, is there any trend towards a reduction in the number of smaller concerns? Table 2.1, showing the distribution of manufacturing establishments by total employees, indicates some tendency towards bigness.

ORGANISATION CHARTS

While the preparation of an organisation chart will not solve all a company's problems, it is, nevertheless, a very useful analytical tool. In a situation of change it should be an essential part of the planning process. On the other hand, it only depicts the situation at a point in time and probably does not reveal the actual subtle interpersonal relationships which are so important. In spite of these shortcomings, the organisation chart can provide the following useful information:

1. The span of each manager's control.
2. The number of levels of authority.
3. An indication of functional and line relationships.
4. Assistance in the preparation of a management development programme.

Fig 2.2, which is an organisation chart for a medium-sized company employing 254 people, provides information on these four points. Although this kind of chart only shows the position of the company at a given time, it is certainly a useful starting-point for analysing certain aspects of the organisation. In the example shown the following implications are apparent:

1. The four production supervisors could have a span of control problem with an average of just over forty people each.
2. Of the eleven managerial positions illustrated, five job holders are nearing retirement, which could create difficulties if their succession has not been planned.
3. While the works manager could be promoted to director, he, the chief accountant, and the technical director are all appraised as being excellent in job perofrmance, but at best only one could get the managing director's job. In this case the chief accountant is earmarked for the position.

Table 2.1

SIZE DISTRIBUTION OF MANUFACTURING ESTABLISHMENTS IN GREAT BRITAIN 1953 AND 1961

Size of firm (Number of employees in each establishment)	*Number and percentage of establishments in each group*				*Number and percentage of establishments in each group*				*Average employees in each group*			
	Number		*Percentage*		*Number*		*Percentage*					
	Jan 1953	*June 1961*	*Jan 1953*	*June 1961*	*Jan 1953*	*June 1961*	*Jan 1953*	*June 1961*	*Jan 1953*		*June 1961*	
11–24 employees	17,177	12,571	30·5	22·8	294,000	222,000	4·1	2·7	17		18	
25–99 employees	25,103	27,478	44·5	49·8	1,249,000	1,420,000	17·3	17·4	50	73	52	80
100–499 employees	11,660	12,213	20·7	22·1	2,427,000	2,552,000	33·5	31.2	208		209	
500–999 employees	1,481	1,693	2·6	3·1	1,017,000	1,163,000	14·1	14·2	687	1,319	687	1,374
1,000 employees and over	986	1,206	1·7	2·2	2,238,000	2,821,000	31·0	34·5	2,270		2,335	
Total (all firms with more than 10 employees)	56,407	55,161	100·0	100·0	7,225,000	8,178,000	100·0	100·0	128		148	

Sources: *Annual Abstract of Statistics* (1953); Ministry of Labour *Gazette*, and Martin Rudd, 'The Small Firm', *Westminster Bank Review* (May 1967).

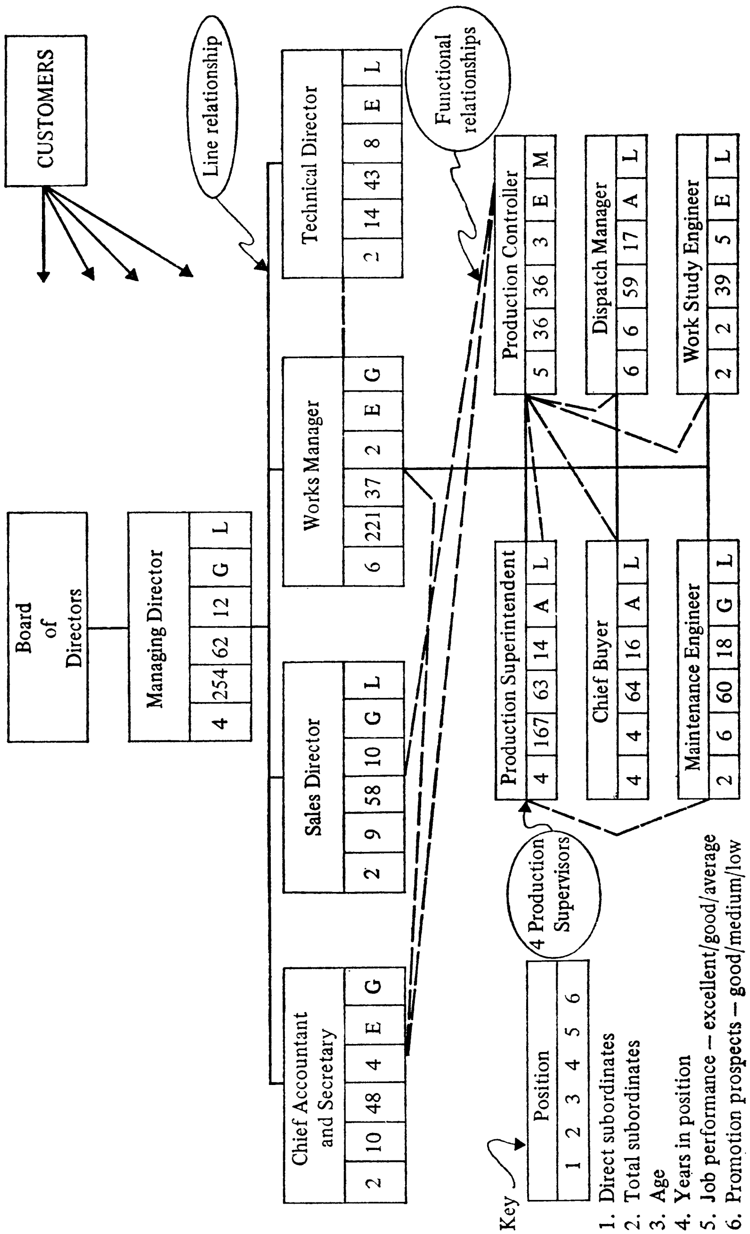

FIG. 2.2. **Organisation chart**

4. The possible need to deal with the average performance of the production superintendent, chief buyer and dispatch manager.
5. Because the managing director has co-ordinated the appraising of job performance, his own has not been included but he estimates his potential for any further promotion to be low.

JOB RELATIONSHIPS

In the light of some of the defects of the organisation chart, and particularly when considering individual jobs, it is perhaps more meaningful to determine the total interaction that takes place for a particular position. The type of hierarchical, or pecking order, structure shown in Fig. 2.2 would become unduly complicated if it tried to show all the interrelationships. Furthermore, it does not reveal the rich layer of political and social interactions. For example, we are not able to see whether one strong production supervisor may really be doing what may be the ineffective superintendent's job. To provide an insight into total relationships, the diagram shown in Fig. 2.3 may be more useful. It is endeavouring to illustrate not only all the people with whom the production controller interacts but also the realities of these relationships. While Fig. 2.2 suggests that the production controller is functionally related, that is, he gives advice, to the production superintendent, Fig. 2.3 exposes the strong personal influence. Indeed, in this relationship, as in some others, the influence eventually takes the form of line or direct authority. Thus every organisation functions as it does because of the people occupying their various roles.

JOB AND TASK RELATIONSHIPS

The increasing attention now given to system analysis means that this approach is widely used for studying organisations. In an article appearing in the *Harvard Business Review* (1967), D. I. Cleland and W. Munsey suggest two major drawbacks to the traditional pyramidal organisation chart:

1. They fail to display the realities of the day-to-day interrelationships. In an effort to overcome this problem they are sometimes supplemented by organisation manuals.

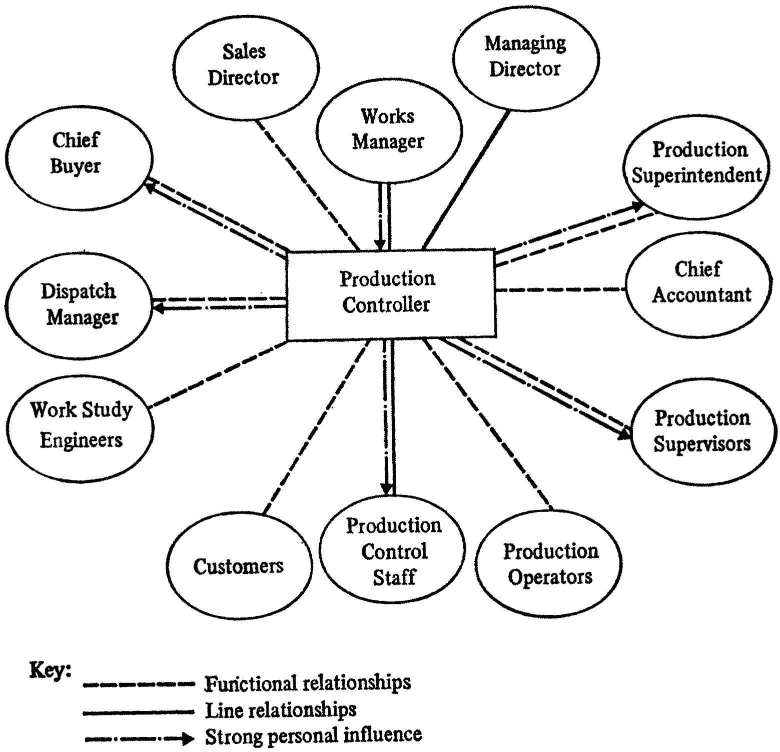

FIG. 2.3. Job relationships for a production controller

2. Only the functional structure is revealed, not the various subsystems.

These two views reinforce points already mentioned, but the article also includes some other factors helpful to understanding:

1. The organisation is composed of many subsystems in regular contact with other groups, such as customers, suppliers, trade unions, creditors, public organisations and so on.
2. Managers have a mixture of roles and like the organisation are also in contact with job holders in other internal and external subsystems. This point is illustrated in Fig. 2.3.

To indicate the interrelationship between roles and tasks, the authors suggest a more dynamic type of chart. A modified version for

Key: Basic Activities

1. Work is done-implement decisions ○
2. Direct supervision □
3. General supervision ⧄
4. Decision influence, 1st level △
5. Decision influence, 2nd level ⟁
6. Decision influence, 3rd level ▲

	Tasks	1 Customer	2 Managing Director	3 Works Manager	4 Sales Director	5 Production Controller	6 Production Superintendent	7 Chief Buyer	8 Dispatch Manager	9 Production Control Staff	10 Work Study Engineer	11 Production Supervisor	12 Chief Accountant	13 Production Operators
1.	Change labour force	△	□	○	⟁	△	▲			▲	▲		⟁	
2.	Change productive facilities	△	□	○	⟁	△	▲			▲	▲		⟁	
3.	Requisition materials		⧄	□	⟁	○		△		△			⟁	
4.	Requisition tools		⧄	□	⟁	○	⟁			△	▲	⟁	△	
5.	Provide delivery promises	△	⧄	□	△	○	⟁	⟁	△	△		⟁		▲
6.	Determine order priorities	⟁	⧄	□	△	○	⟁			△		△		
7.	Make change in hours worked	△	□	○	⟁	△	⟁			⟁		⟁		⟁
8.	Subcontract work	△	□	○	⟁	△	▲			⟁		▲		⟁
9.	Provide control data		⧄	□		○	⟁	⟁	⟁	△	⟁	△	△	
10.	Load work to facilities		⧄			△	□			△		○		△
11.	Produce orders					△	⧄			△	△	□		○
	□ Total tasks	6	10	9	8	11	10	3	2	11	5	8	5	5

Task summaries

○	=	11
□	=	11
⧄	=	7
△	=	28
⟁	=	26
▲	=	10

FIG. 2.4. Role and task relationships chart: production control function

the production control function is shown in Fig. 2.4. The relationship between eleven tasks and thirteen roles is examined and compared with six basic activities. This kind of chart shows who actually does the work, or makes the decisions, and the related roles and activities. The tasks and activities are also listed in order of a logical work flow. What also becomes apparent is the significance of the production controller, for example. He is making five of the eleven possible decisions and has a direct or first-level influence on the other six.

OBJECTIVES

Another obvious, but often overlooked, aspect of the works organisation is the determination of objectives. If the question is put to the practising manager 'Are you working to objectives?' he will probably reply 'Don't be stupid, of course I am.' While he may be working to achieve some aim, this may not be clear to the various people, particularly his subordinates, with whom he works. Furthermore, the objectives may not have been expressed in measurable terms. Therefore, working to measurable and clear objectives should unarguably be a natural part of every company, with the proviso that determining desirable objectives and motivating all members of management may not be easily achieved. Again with the proviso that it is possible and perhaps desirable that individual managers should set their own objectives, the latter will probably be more effective if set within an overall company plan. Objectives need to be stated in terms capable of measurement. This is clearly essential for determining whether aims have been achieved. Finally, some kind of control or feedback system is needed so that remedial action can be taken and managers can see where they are not achieving results. This whole process, as it might apply to a works organisation, is summarised in Table 2.2.

While a management by objectives system will not necessarily work in every company – it would be surprising if it did – it can be a useful diagnostic tool for revealing weaknesses. For example, a study of the main areas of works performance as listed in Table 2.2 could be used as a simple start to improve at least some of these areas.

JOB DESCRIPTIONS

At the risk of reiterating an aspect of company effectiveness all too often taken for granted, an organisation is only as good as the individuals in it and how they work together. This is maybe the whole nub of the problem and so long as people continue to be different, the problem of co-ordination will remain. This inherent difficulty does not mean to say we cannot improve matters. A partial answer to directing individual activity to company objectives is through job descriptions. If they are realistically agreed by the boss and the subordinate in a participative climate they can be of value. Some

Table 2.2

BASIC CONTROL SYSTEM FOR A WORKS ORGANISATION

Basic objective	*Measurement of performance*	*Control*
Delivery performance	1. Percentage of orders which are late 2. Maximum acceptable overdue period	1. Weekly delivery performance statement
Output	1. To be within agreed percentage of target 2. Average production time not to exceed agreed period	1. Weekly output report
Quality	1. Scrap to be kept within agreed percentage 2. Customer complaints to be no more than stated number per month	1. Weekly scrap return 2. Monthly inspection report
Facilities and direct labour	1. Maintain existing plant utilisation 2. Maintain existing direct labour efficiency	1. Weekly plant and labour statement
Stocks	1. Raw material to be maintained at budget 2. Work-in-progress not to exceed stated number of weeks at any stage	1. Weekly production control report
Costs	1. Maintain existing direct labour cost 2. Reduce indirect labour cost by agreed percentage 3. Overtime not to exceed stated total hours	1. Weekly cost control statements
Personnel	1. Reduce absenteeism by agreed percentage 2. Introduce supervisory training scheme by agreed date 3. Introduce joint consultative committee by agreed date	1. Weekly labour control 2. Monthly personnel report

managers, of course, find the whole idea of the job description a restraining influence on their style, but even the thrusting self-starter needs to be kept pointed in the right direction. In any case, the descriptions should be skilfully developed to suit the joint needs of the company, and the particular boss–subordinate relationships.

STUDY WORK

To increase your understanding of your own organisation, you might find it useful to develop charts similar to those shown in Figs. 2.2, 2.3 and 2.4. Even a traditional organisation chart such as Fig. 2.2 could reveal age or span of control problems.

In addition to the points already made, the main aspects to be considered in preparing a job description are as follows:

1. Although there will be static parts of the job, recognise the dynamic nature of management. The job description therefore requires regular review.
2. It must be developed jointly by the boss and the subordinate with an acceptance of how they influence each other's performance and in turn are affected by various other people. This point is illustrated in the job and role relationship.
3. If job descriptions have not been used before, a good deal of patience will be necessary before they lead to improvements.
4. The descriptions will probably reveal other organisational weaknesses.

An example of a job description is shown on p. 40. The position of production controller has been chosen so that it can be related to everything already said about Figs. 2.2, 2.3 and 2.4.

SUMMARY

This chapter attempts to show some of the theoretical aspects of works organisation alongside some practical ways of understanding them. There is no doubt that the structure and working relationships play a very significant part in effectiveness, but the way people get things done is probably unique to the situation in which they find themselves. We can only understand and improve this situation by careful inquiry, clarifying our objectives, and creating and main-

JOB DESCRIPTION

Title: Production Controller.

Purpose:

To co-ordinate all production control activities so that an acceptable delivery performance is maintained consistent with the most effective utilisation of direct labour, plant and production materials.

Job Relationships:

(i) Responsible to Works Manager.
(ii) Directly supervising:
  Material Controller (4)
  Programmer (4)
  Order Record Clerk (5)
  Chief Storekeeper (12)
  Supervisor of Material Movement (6)
 Figures in brackets indicate subordinate's responsibility.
(iii) Total subordinates (including direct subordinates): 36.
(iv) Other direct organisational relationships:
  Production operators
  Production supervisors
  Production Superintendent
  Sales Director
  Chief Accountant
  Chief Buyer
  Managing Director
  Dispatch Manager
  Work Study
  Customers.

Job Dimensions:

(i) Can sanction purchase requisitions for all production materials.
(ii) Can sanction tooling requisitions up to £500 per item; above this figure requires approval from Works Manager.
(iii) Can sanction stationery requisitions up to £100; above this figure requires approval from Works Manager.
(iv) Required to submit a monthly statement of:
  Delivery performance
  Plant utilisation
  Direct labour utilisation
  Work-in-progress
  Output of major products.
(v) Responsible for wages/salaries budget of £420 per week.
(vi) Responsible for a stationery budget of £210 per week.
(vii) Responsible for selection of staff and for discipline.
(viii) Increases in staff must be sanctioned by Works Manager.
(ix) Dismissals must be sanctioned jointly by Works Manager and Personne Manager.

Areas of Discretion:

(i) Requires skilful interpretation of sales information to forecast the likely implications for the company's productive resources, and to make recommendations for appropriate action.
(ii) To take effective short-term action as the result of changes in customer and production requirements.
(iii) To act as an effective buffer between production and sales and customers.
(iv) Through the Production Superintendent and Production Supervisor to advise on the best use of their resources consistent with delivery requirements.

Accountabilities:

(i) To submit monthly report within one week of end of month.
(ii) To achieve agreed delivery performance.
(iii) To achieve agreed resource utilisation.
(iv) To initiate appropriate changes in productive resources.
(v) To develop production control staff.

taining an atmosphere where people can perform. Hopefully, some of the pitfalls and a few tools that might help have been revealed. The way work flows through the company and the basic works functions will be examined in the next two chapters.

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3 | Manufacturing Systems

HISTORICAL DEVELOPMENT

Since the beginning of the Industrial Revolution it is possible to trace three stages of development. In the first, man's muscle power was gradually replaced by the power of new machines. Then during the last twenty to thirty years, through the advent of numerical control, man's directional power has also been replaced by machines. Only comparatively recently has attention been paid to the third stage – the design of total manufacturing systems. The complexity of organisations makes this a large problem, so it is not surprising that our understanding of it is still somewhat elementary. Nevertheless, with the spread of cheap computers work is proceeding so that in time even the small concern will be able to afford more sophisticated control equipment. In an article on the future of manufacturing systems, B. Davies (1971) notes also the complementary management information system's importance and the way it should be exercising control over the company's key areas.

SYSTEM CHARACTERISTICS

In the two previous chapters the manufacturing, and in many respects the non-manufacturing, organisation has been shown to be basically an input/output system seeking to satisfy varying market demands at minimum cost. Generally speaking, the product and the quantity made most influence the manufacturing system. These two factors affect, among other things, factory size, plant layout and the distribution of manufacturing cost. Joan Woodward (1958) in her study of production methods divided them into three groups:

Group I	Small batch and unit production
Group II	Large batch and mass production
Group III	Process production.

Group I is characterised by work queueing between operations so that similar items of plant are grouped together into what is called a functional or process layout. Groups II and III involve much less

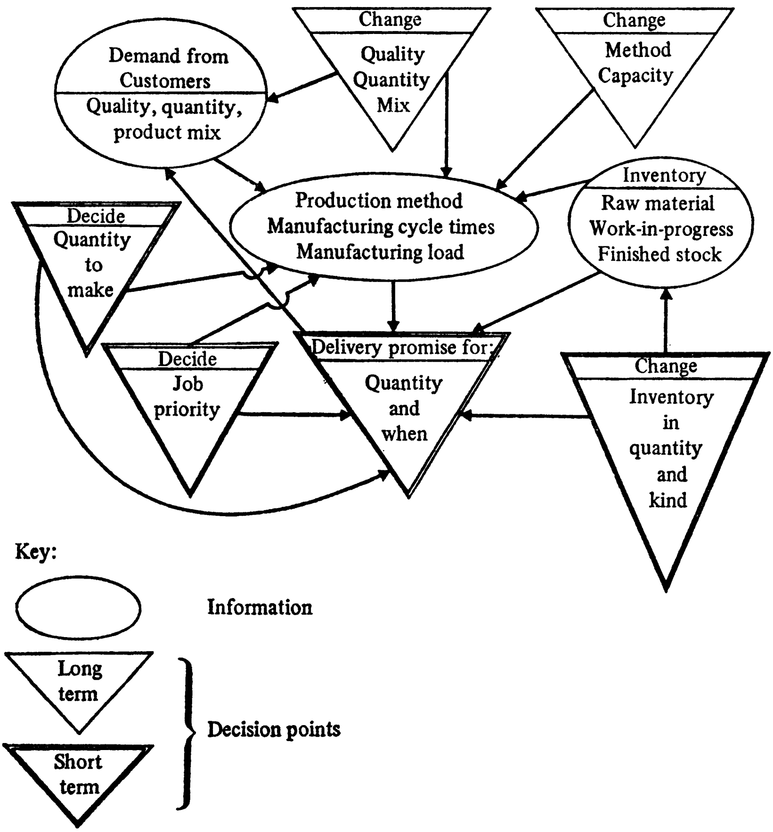


FIG. 3.1. Information and decisions in manufacturing systems

queueing; in fact process manufacture's production flow is continuous. In these two methods the plant is laid out to suit the product operation sequence and hence described as a product or line layout.

Clearly, any manufacturing system involves much more than the mere positioning of equipment; as already indicated, it is concerned with the interaction of many economic, technical and social factors.

At its simplest, and ideally, any company would like to know when customer demand has so changed that the manufacturing system also needs changing in some respect. If only sufficient comparative data were available, many set-ups would be altered in some way. The principal factors for attention are shown in Fig. 3.1. It will be seen that information is required in three important areas: customer demand, manufacturing capacity and inventory. Certainly, output and delivery forecasts depend upon the last two, but the longer-term decisions to change the arrangement and quantity of productive facilities clearly call for a continuous interpretation of customers' requirements. This latter point, of course, takes us straight into the area of managerial economics and forecasting. It is, nevertheless, an important aspect if the production set-up is not to become obsolete.

VARIABLES IN SYSTEM DESIGN

If the manufacturing part of the organisation is going to respond effectively to change, it will need to know how to set about designing a new system. This necessitates identifying those variables which affect efficiency. Once these variables are isolated, it may be possible to assess the effects of changing some of them through the use of simulation techniques. Professor B. W. Saunders (1962), in a study of manufacturing system design, describes a simulation method for comparing the relative advantages of a line and a functional layout. To do this, a list of criteria for evaluation needs to be determined. Such a list is shown in Table 3.1. Measurement is crucial in this kind of analysis; without it, it is wellnigh impossible to assess performance or to evaluate the effects of changes in the system. Nevertheless, the criteria listed in Table 3.1 require regular monitoring, if production management is to be efficient.

PRODUCTION LAYOUTS

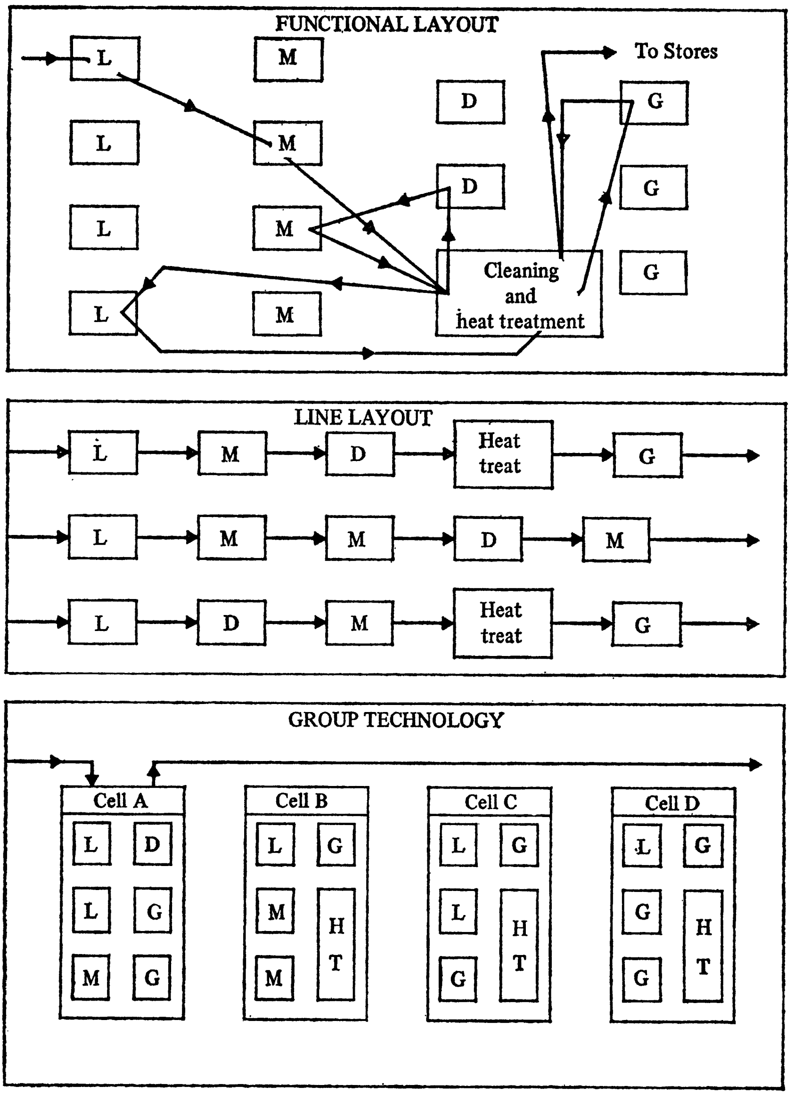
So far, only brief reference has been made to functional and line layouts. Because this aspect is known to have a significant influence on efficiency, it deserves more attention. Also worth attention is a third type of layout known as cellular manufacture, which is a variation of group technology (GT). Each of these three types is shown diagrammatically in Fig. 3.2.

Table 3.1

CRITERIA TO BE USED IN SYSTEMS DESIGN

No.	*Criteria*	*Measurements*
1.	Order pattern	Size of each product group. Distribution of order size. Fluctuations in demand.
2.	Inventory divided into raw material, work-in-progress and finished stocks	Value at each stage, also expressed on a time basis. Relative increase in value at each manufacturing stage.
3.	Times to carry out each operation plus the times and distances to move from operation to operation	Standard times and distances.
4.	Cycle time from receipt of order to dispatch to customer	Actual delivery times. Item 3 divided by item 4 equals the stagnation factor mentioned in Chapter 1.
5.	The kind and arrangement of plant	Special or general-purpose plant. Line or functional layout.
6.	The distribution of operator skills	Wages analysed into unskilled, semi-skilled and skilled.
7.	Plant and labour utilisation	Operating time divided by available time or planned time.
8.	Inertia of the system to changes in product mix	Changes in item 1 and their effect on items 2, 3, 4, 6 and 7.
9.	Sensitivity of the system to changes in product mix	How quickly are changes in items 1, 2, 3, 4, 6 and 7 revealed?
10.	Nature of maintenance system	Effect of down-time. Maintenance costs. Down-time costs.
11.	Complexity of production planning and control	Number of orders. number of processes. Number of unplanned events, such as additional operations, scrap, rework, etc. Wage bill of production-control department.

The functional layout is the most prevalent and is generally found in the company producing a large range of products in small to medium-sized batches. As previously noted, it is characterised by queues of work and similar plant all grouped together. For large-quantity manufacture the line layout is used. In recent years industry and a number of universities have been devoting attention to a



Key: L = lathe → Direction of production flow
M = miller
D = driller
G = grinder
HT = heat treatment

FIG. 3.2. Production layouts

manufacturing system known as group technology, which includes the concepts of cellular production, production flow analysis and batch flow. This system seeks to obtain some of the line layout's advantages for the concern engaged in small batch and unit production.

Experience shows that even in the complex conditions of small-quantity manufacture there are significant product and process patterns. Principally, it has been shown that large percentages of components all require similar productions processes. These groups of parts are called 'families' and the associated processes are designated 'cells'. There tend to be two broad approaches to the preparatory analyses for GT. The first is based upon the component shape classification developed by Brisch (1966) and Opitz (1964). Secondly, the parts may be divided by machining characteristics as in the production flow analysis method developed by Burbidge (1963). An NEDO (1966) report lists the following improvements from the application of cellular production at Audco Ltd:

Sales	Up 32 per cent
Stocks	Down 44 per cent
Stock to sales ratio	Down from 52 to 25 per cent
Manufacturing time	Down from 12 to 4 weeks
Overdue orders	Down from 6 weeks to under 1 week
Dispatches per employee	Up about 50 per cent
Capital investment	Cost recovered four times by stock reduction alone.

Audco's results will not of course be matched by every company and such improvements are not obtained overnight. Furthermore, this kind of change most probably necessitates a reclassification of components into a form suitable for computer analysis. Whatever one's personal view, the performance increases achieved provide a useful list of objectives for any manufacturing system. Indeed, Audco stated as their overall target: 'To deliver products on time and arrange the operation so that the time required is truly the minimum necessary.' In addition, an analysis of production flow reveals that plant arrangement and work-in-progress are two important factors in the achievement of this objective. A fuller explanation of group technology is given in the volume of this series entitled *Techniques for Production Efficiency*, by Ken Swann.

PLANT SIZE AND FACTORY SITING

To increase understanding of the way work is processed, it is useful to study the nature of decision-making. A large part of any company's resources will be found in the works; therefore day-to-day decisions about their use clearly warrant attention. Not only the routine short-term matters but also the unique longer-term decisions merit examination. The latter kind can probably be grouped into decisions about factory siting, size of plant and production method. Each one of these can have far-reaching effects on factory efficiency, since once the company has committed itself to a particular course of action, there can probably be no going back. In all likelihood most businesses, big and small, will at some time have to consider increasing their productive capacity. In many cases a new factory is the only answer, but it is always worth first considering the following alternatives:

1. Can additional capacity be obtained from the existing factory by:
   (*a*) Improved manufacturing methods?
   (*b*) Changing the production method, e.g. from a functional layout to group technology?
   (*c*) Improved plant?
   (*d*) Productivity bargaining?
   (*e*) Overtime working?
   (*f*) Shift working?
2. Is it possible to extend the existing factory?
3. Can subcontracting be adopted?

If after considering these alternatives it is still not possible to satisfy the increased production requirements, then two small interrelated decisions are necessary: firstly, the size of plant; secondly, its geographical location. As with all aspects of running a business, risk attends the expansion of capacity, and while that indefinable intuitive feel is important, costly mistakes can be lessened by an objective analysis. Plant size is, of course, very much influenced by market demand and sales forecasts. Forecasts beyond some five to six years are generally considered not very reliable. With this proviso, R. M. Lawless's (1962) article in the *Harvard Business Review* suggests four alternative courses of action:

Decision 1 Build to suit the six-year forecast.
Decision 2 Build to suit the three-year forecast and, if necessary, during the third year extend to suit the six-year forecast.
Decision 3 Build to suit the two-year forecast and, if necessary, add two stages of extension to meet the fourth- and sixth-year requirements.
Decision 4 Build the minimum-sized factory to suit the first-year forecast and, if necessary, add one extension per year up to the sixth year.

As with any kind of effective decision-making, an evaluation of these four alternatives is dependent upon relevant information. It is self-evident that sales forecasts and factory costs are required. In addition, it is essential to know about such factors as product and process risk, plant flexibility, plant life, construction time, inflation effects on excess capacity and rate of return expected.

The decision about the size of factory to be built must be followed by the choice of a suitable site. Although this decision also tends to be somewhat subjective and is influenced by government action, it can nevertheless benefit from a systematic analysis. A useful check list is shown in Table 3.2. Wherever possible, the variables listed should be quantified so that alternative sites may be numerically compared.

DECISION POINTS

Besides the more important, long-term decisions, day-to-day decision-making deserves attention. When someone in a company decides to requisition production materials or to give a delivery promise, he is committing either the company's resources or its reputation. It is therefore important to know by whom and where such decisions are made and, of equal importance, how they are reached. In some cases, particularly in the complications of batch systems, flair and intuition combined with experience are often effective. Wherever decisions – by no matter what method – are reached and wherever information is stored, there must be a feedback or control system to check on progress.

The short-term decision points illustrated in Fig. 3.1 can be grouped, as shown, into four areas:

Table 3.2

VARIABLES INVOLVED IN CHOOSING A FACTORY LOCATION AND SITE ANALYSIS SHEET

Main variable	*Sub-variable*	*Answer*
Location:		
1. Product markets	(a) Transportation costs to areas of customer demand (b) Transportation facilities	
2. Productive materials	(a) Transportation costs to new factory	
3. Labour	(a) Wage rates in area (b) Availability of skills required	
4. Trade unions	(a) Strength in the area (b) Attitudes in the area	
5. Employee attractions	(a) Social amenities (cinemas, parks, libraries, etc.)	
6. Government influence	(a) Planning requirements (b) Pollution control	
Site:		
7. Sales forecasts	(a) One-year forecast (b) Two-year forecast (c) Three-year forecast (d) Four-year forecast (e) Five-year forecast (f) Six-year forecast	
8. Plant cost	(a) One- to six-year forecasts	
9. Floor area required	(a) One- to six-year forecasts	
10. Processing requirements	(a) Production method (b) Type of layout	
11. Accessibility to transport	(a) Supplies in (b) Products out	
12. Employee attractions	(a) Medical facilities (b) Housing available	
13. Site factors	(a) Area, shape and gradient (b) Tenure (c) Costs/rates/services insurance	

1. Determining delivery promises on the quantity to be produced and when it will be available.
2. Changing the inventory in some way, which can be a combination of quantity and kind.
3. Deciding upon the sequence in which the various jobs will proceed through the various processes.
4. Deciding what quantity to make.

Each of these decisions will be influenced by the amount and quality of information available and the decisions' effectiveness will, of course, have a strong influence upon the company's productivity and its standing with customers. Lawlor's (1967) study of the job sequencing decision showed that the supervisor decided job priority and that the order of importance for the factors influencing his decision was:

	Rank	*Job factor*
	1	Week when job was due
	2	Utilisation of plant
Equal rank	3	Output
	3	Requirements of other operations
	4	Time to complete batch on remaining operations
	5	Piecework requirements of operators

This study also included an investigation of the delivery promise decision which revealed the following results:

	Rank	*Factor*	*Information availability*
	1	Customer delivery request	Quite often
	2	Details of product	Quite often
Equal rank	3	Work content of order in hours	Only partially
	3	Directions from management	Very often
	4	Load on all plant	Only partially
	5	Delivery promise of productive materials and tools	Very often

The customer clearly influences the decision, yet the important factor of the existing plant load ranks near the bottom. Furthermore, it is an item which is not supported by complete information. Notwithstanding that many companies face this difficulty, its effect upon the factory's general performance ought to be recognised.

SUMMARY

These further steps in the task of analysing the factory set-up have dealt with the subject rather more technically than did the previous chapter. In most manufacturing organisations the product itself and the quantity made have a significant influence upon the total manufacturing method. In this context method includes the type of plant, its arrangement and the decision-making and control systems. Two things seem important in this type of analysis: firstly, to determine whether there are other manufacturing systems which could be more effective than the existing one; secondly, periodically to check whether the product mix has so changed that the existing system is inadequate. For example, could a functional layout be advantageously replaced by a cellular or flow arrangement? This all means that a set of criteria must be used to measure performance – a fundamental requirement, anyway.

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4 | Basic Work Function

GENERAL MANUFACTURING CHARACTERISTICS

In Chapter 1 it was suggested that there are five basic company activities: accounts, design, personnel or wages, sales and manufacturing. Self-evidently, a company's success depends upon how these five activities are co-ordinated, yet particular attention must be directed to the manufacturing aspect.

Martin's article on 'Productivity Costing and Management' (1970) suggests that the value added to materials in the production process is management's primary objective. It also states that management is the achievement of objectives through control of the organisation. These two useful insights simplify study of the manufacturing organisation by concentration upon three areas:

1. **Work flow.** Sometimes cynically described as where the Indians are who actually do the work, it is certainly where materials are changed in some way and have value added. The personnel working here will be operators and those who co-ordinate their activities, such as supervisors and production management. The major concern at this level is the amount of time when value is really added, or the amount of time spent on truly productive work.
2. **Service and control functions.** For work flow to continue in an efficient, uninterrupted manner, the people involved need advice and guidance on such matters as the sequencing of orders, the best production methods and required quality standards. Such advice and guidance is generally provided by service or functional departments such as production control, work study and quality control. These also provide feedback on how well the standards of performance are being achieved. Another important service requirement is that it rectifies the wear and tear of

the productive process. This is usually called maintenance and would embrace both plant and tooling. In addition to maintaining equipment in a satisfactory condition, this broad maintenance function would also be involved in the decision to replace plant and invest in new facilities. Finally, overshadowing the whole operation is the need for control on work flow, costs and quality standards.

3. **Works organisation structure.** While it is true that people mould their own jobs and influence the character of the organisation, conversely their performance is no doubt affected by the particular company where they work. Indeed, one important talent required by the effective manager is the ability to work through his own power organisation – a skill at which some are better than others.

Nevertheless, we can all perform better if the organisational climate is right. Apart from the style of managing people, it is essential to clarify role responsibility and to create functions as they become necessary. On the one hand, people need interesting jobs with some challenge; on the other, as the situation changes, so should the job and possibly the organisation structure, too.

A typical example is the growing company where the production manager has to employ a buyer because he can no longer cope with this activity himself. The works organisation structure, or the relationship between jobs, has already been discussed in previous chapters, so what is needed now is to examine in more detail the basic works functions. Although these will be discussed separately, it should be remembered that particular job holders may from time to time perform a number of duties even though officially they should do only one of them.

The first two areas of the manufacturing organisation are now discussed in more detail.

1. *Work Flow*

At this level the value-adding activities' time must be sharply distinguished from everything else. To this end, setting-up, adjustment and clearing-away times will be excluded. Some readers may disagree with this scheme, the purpose of which is to ensure that a similar language is used throughout. The point will become more significant when measurements of plant utilisation are examined. Typical basic work-flow operations are those which change materials' shape, change their physical structure, add surface finish or join together. The supporting, but nevertheless important, activities may be listed thus:

(*a*) Set up, adjust, clear away.
(*b*) Transport material to and from the point where work is done, including, where appropriate, moving work from floor to machine.
(*c*) Direct the work of those actually engaged in work flow. This will generally include such personnel as setters, leading hands, chargehands and foremen.

Naturally, suitable plant arranged in an efficient way plays an important part in work flow. It is interesting to note, as Martin (1970) has suggested, that if adding value is a primary objective of management, then by implication operators are involved in the management process. Furthermore, it is surprising how many operators also influence the directional aspects of work flow, unless one realises the importance of initiative at all levels. What probably requires closer study is how to increase the time when value is really being added. Furthermore, perhaps the added value or total earnings concept may promote more understanding and agreement over the age-old problem of sharing the cake.

2(*a*) *Service Functions*

Though one measure of efficient material flow through the manufacturing system is the ratio of added value to operating costs, that flow will need a supporting service. The latter, which can be briefly described as plan, receive, store, move and maintain, frequently involves the following departments:

(*a*) **Scheduling** or **programming,** which date-plans new orders and decides customer delivery promises.
(*b*) **Technical** or **process planning,** responsible for determining the manufacturing sequence and tooling required; sometimes also includes the task of estimating operation times.
(*c*) **Material** and **tool planning** schedules delivery dates for bought-out materials and production tooling. Material will

probably be the responsibility of the buying department and tooling of technical planning.

(*d*) **Goods receiving** checks quantities and sometimes quality of incoming materials and directs them to stores or appropriate production points.

(*e*) **Stores,** which can include three stages: raw or pre-production materials, work-in-progress, processed parts and finished parts.

(*f*) **Materials movement,** which can be a formal section with official responsibility for moving work between operations and to recognised work-in-progress areas. On the other hand, it can be an informal activity done by labourers, operators, foremen and even managers. This clearly important activity can add only costs, not value, and if carried out inefficiently it can even lower the rate at which value is added.

(*g*) **Maintenance,** clearly an important function if production facilities are to be available for their intended purpose.

These are the seven basic service functions. The design department, which can be regarded as providing a service, has not been included because it generally falls outside the authority of the works.

2(*b*) *Control Functions*

An inherent characteristic of any manufacturing system is some kind of feedback or control activity. It may not be immediately apparent, yet various aspects of works activity will be compared with what was expected and, if unsatisfactory, will lead to corrective action. In some cases, a sophisticated computer-controlled feedback system will operate; in others, it will simply take the form of the works manager exerting pressure on a foreman for not completing certain orders. The main control functions were stated in Chapter 1 as controls over cost, quality and production or work flow, the latter control being primarily concerned with time and quantity. Implicit in the concept of control is the need for someone to take action when deviations from laid-down standards occur. The cost standards will generally be determined jointly by the cost department, design and process planning, quality standards by design and inspection, and work flow in terms of time and quantity by the scheduling department. The principal control points are shown diagrammatically in Fig. 4.1.

	CONTROL POINTS					
	1	2	3	4	5	6
Activity	Order acknowledgement	Material delivery	Tool delivery	Goods receiving and stores	Work flow	Dispatch
Responsibility	Scheduling	Buying	Process planning	Stock control	Works management	Scheduling
Determination of standard	Customer Available capacity Material Tools	Scheduling Suppliers	Scheduling Available capacity	Scheduling Cost	Scheduling Process planning Cost	Scheduling
Standards or Plan	Date Quantity Quality Cost	Date Quantity Quality Cost	Date Quantity Quality Cost	Date. Quantity Quality Cost	Date Quantity/Rate Quality Running time Cost	Date Quantity Quality Cost

↓

Compare with standard or plan and take action if necessary

FIG. 4.1. Principal control points

SUMMARY

A manufacturing company, whatever its size or kind, has now been shown to be primarily concerned with how efficiently it can maintain work flow or those processes which really advance the material towards a saleable product. Furthermore, if this process is to continue in an efficient manner, it requires adequate supporting functions, for example scheduling and maintenance. Finally, the systems approach requires standards of performance to be established and follow-up remedial action to be taken whenever there is failure to achieve the standards.

In most companies, at least on the informal level of activity, there will be some overlapping of the functions described. This will apply particularly in the smaller company and in the complex situation of jobbing or batch systems. Provided the set-up works and results are satisfactory, is change really necessary? To make sure, there should be regular monitoring of the control points shown in Fig. 4.1. Any area of unsatisfactory performance should be examined for causes. Likely reasons could arise from a number of factors, including a poor feedback system or one person trying to perform too many functions. The areas requiring the closest vigilance are production control, maintenance and inspection which are dealt with in the next two chapters.

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5 | Production Planning and Control

THE SIGNIFICANT SERVICES

As indicated in previous chapters, there are a number of so-called service functions in the company. Of these, probably only three are significant. Firstly, there is the one that organises and controls work flow in what is generally called production planning and control. Secondly, the production processes require to be kept in an efficient condition, a service provided by the maintenance department. Thirdly, technical standards are generally watched over by an inspection and quality-control function. (Of course, another significant function is controlling the use of money, but this is dealt with in another book in this series). An examination of these three services will show that they also embrace other areas of support such as purchasing, stores control and work movement.

OBJECTIVES OF PRODUCTION PLANNING AND CONTROL

Any manufacturing concern is constantly trying to utilise largely fixed internal resources with a changing external demand for its particular production services. This means that once the plant has been installed in a building and employees of particular skills engaged, the situation cannot be altered in the short run, yet the market will demand both short- and long-term changes. It is therefore necessary that production management, with the advice of an efficient planning and control service, should be aiming to programme all manufacturing resources as best they can in the light of this shifting situation. At the same time, they need to signal when the time has come to alter facilities in some way. This is partially a sales and forecasting activity, but it is logically unwise to separate sales and production management. Although it is easier said than done, from all this can be deduced the overall objective of getting the results of production to the market at the right time, with the required qualities, consistent with an economical use of resources. The right price has been excluded because this is very much a sales responsibility.

DIVISIONS OF PRODUCTION PLANNING AND CONTROL

This overall activity of organising work flow can be divided into the following three activities:

1. **Interpretation of customer demand.** As mentioned before this aspect involves analysing the short-term effects of current requirements. It also includes the exposure of any significant changes required.
2. **Programming production facilities,** sometimes called **pre-production planning.** This is the activity which decides what resources are required and when they are required to satisfy specific customers' orders or a general market demand. The factors which usually require attention are:

   (*a*) Product drawings and specifications.
   (*b*) Equipment and tool details.
   (*c*) Production materials.
   (*d*) Availability of appropriate productive capacity.

   All this, of course, implies that information exists on how much each one of these factors has been committed with existing demands, which in turn raises the problem of the cost and accuracy of such information. What needs to be decided is what is essential and how accurate it need be. Reasonable estimates provided quickly are better than figures to three decimal places presented a month later. Sometimes scheduling is used to describe programming. Scheduling involves the sequencing of 'live' work through the manufacturing system and should require reference to the plan established at the programming stage. Bearing in mind the short-term changes in demand, some alteration in the original plan may be necessary. The production controller's dilemma is being able to see the complete picture and how best to manage it with the conflicting demands of delivery, output, plant and labour utilisation and inventory. It can be demonstrated by simulation methods that it is highly unlikely that each one of these factors could all be maximised, particularly in the jobbing or batch system.

3. **Control.** Two levels of control are necessary: firstly, a general control dealing with output, delivery performance, resource utilisation and inventory value; and secondly, a monitoring of the individual position of customers' orders, tools, materials and the work load on machine groups. A control system must not only signal deviations from the accepted plan, but most also provide a stimulus to corrective action.

INTERPRETATION

The three broad divisions of production planning and control briefly outlined can now be explored in more depth, together with the associated subdivisions. The more important aspects of 'order interpretation' are shown in Table 5.1. Anyone involved in works management will know that production control is a complex job and although good procedures help, life will never be straightforward.

Table 5.1

ORDER INTERPRETATION

Factor	*Method of analysis*	*Effect on*
Order quantities, e.g. change in the relative numbers of small-quantity orders or a change in the order intake	Order size frequency distribution	1. Progress activity 2. Output 3. Resource utilisation 4. Amount of inventory 5. Amount of capacity for setting up plant 6. Operators' piecework performance 7. Plant capacity 8. Profitability
Product change	Percentage change relative to other products	1. Capacity of certain items of plant (some may increase while others could decrease) 2. Space for storing inventory stocks 3. Delivery cycle times
Product materials	Percentage change relative to other products	1. Plant capacity 2. Manufacturing skills 3. Supply position

One important task is to be constantly monitoring any significant changes. For no matter how good the paper system, there will be increasing confusion if the manufacturing system is becoming unsuitable for a changing product mix. The three main areas of likely change suggested in Table 5.1 need not necessitate much involved record-keeping; indeed, any control system must be simple and cut to its bare essentials.

AUTHORISATION AND ORDER ACKNOWLEDGEMENT

An important but often overlooked part of organisation for manufacturing is how productive work is authorised and delivery dates acknowledged to the customer. If resources like design skill, materials,

Table 5.2

AUTHORISATION AND ACKNOWLEDGEMENT PROCEDURE

Activity	*Procedure*
1. Order received from customer	1. Add to record for monthly analysis for interpretation of trends 2. Pass to Works Manager if order requires any significant resources, e.g. 10 per cent of total capacity. Assess implications
2. Determine delivery details as to date and quantity	1. Determine availability of technical information, tools and materials 2. Compare with existing load on plant and establish delivery date 3. Add order details to existing load on basic resources
3. Notify delivery details to customer	1. Monitor acknowledgement date with target date

tools and productive capacity are to be committed, then there should be a formal procedure to control the decision-making involved. In the mass-production industries where resources need to be sanctioned, often in large amounts, in advance of sales, authorisation will be made at board level. In jobbing or batch companies which are generally making to specific orders, then the customer's order is the authority and can be dealt with at production management level. It is in this kind of industry, producing small to medium quantities, that there is also a need for a simple acknowledgement procedure. Such a procedure should include a target time, say seven days, by which the customer should be informed of details of delivery. In an NEDC report (1969), it was shown that delivery performance is just as important as price. The report also pointed out that there was much confusion as to the precise meaning of 'delivery date'. A suggested procedure for the authorisation and acknowledgement of orders in a medium-sized engineering company making to customer's order is shown in Table 5.2.

PROGRAMMING

As previously noted, the programming function is concerned with ensuring in advance that all the requirements for each order will be available when needed. The items which necessitate pre-production planning are technical information, materials, tools and production capacity. These will be dealt with as subfunctions of programming.

Technical Information

This includes drawings, lists of parts and materials, operation sequence, details of tools and inspection equipment, production processes and operation times. In some cases, for entirely new products, this information will need to be created for the first time, while for repeat orders it need only be reissued. The amount of technical information will depend upon the numbers of products to be made. Large-quantity production will necessitate detailed technical planning with complete tooling and gauging for each operation, while small-quantity production will require much less and in consequence depend upon the skill of work-flow personnel. The amount of technical support to be provided can be determined by economic analysis, but in the large majority of companies which still produce in small to medium quantities, simple planning and control are needed with an organisational climate which guides and encourages initiative at the work-flow level. Too often one is tempted to plan and control far from where the product is made. If the realities are such that problems have to be solved on the factory floor, there is bound to be conflict between the operatives and the planners. Another important decision that is quite often necessary at the pre-production stage is the quantity to be made in each batch, including allowances for possible scrap. In reality the batch size decision is often made intuitively, but certainly in the company making in small to medium quantities it is a significant area for attention. The main factors which influence batch size can be listed thus:

1. Time and cost to set up and unset plant.
2. Production rate.
3. Customer demand or quantity required in a given period.
4. Plant running cost.
5. Inventory carrying charges, which include interest on capital tied up, and storage costs.

Burbidge (1959, 1971), who is critical of economic batch quantity theory, suggests that more attention should be paid to production flow analysis and to developing methods for reducing setting-up costs. In the study made by Lawlor (1967), the most important factors affecting batch size were:

1. The material value.
2. The quantity ordered by the customer.
3. Expectation of repeat orders.
4. The size of the product.
5. Ensuring customer received the quantity he ordered.
6. Personal experience of order clerk.

A somewhat similar decision is that of the scrap allowance or what is also called the shrinkage allowance. The factors which need to be considered are similar to batch quantities, but should also include the probability of scrap. The main stages in the planning of technical information, together with date and inventory planning, are shown in Fig. 5.1.

Inventory Planning

A vitally important aspect of any manufacturing business is the planning of its inventory. These are the previously mentioned throughput materials which when converted generate the earnings which sustain all parts of company activity. The effective use of materials is influenced by a number of factors, but the more important ones are:

1. Design, which largely determines the kind, quantity in each product, and yield of materials.
2. Production method; for example, a company engaged in

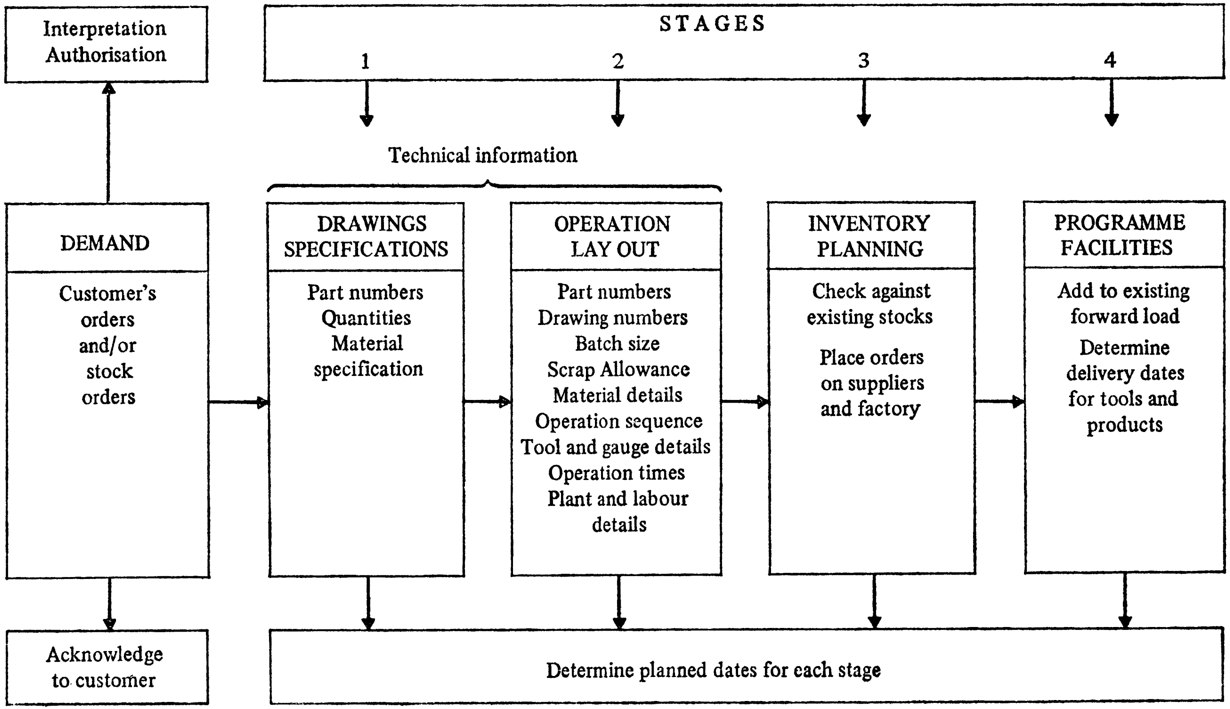


FIG. 5.1. Stages in pre-production planning

jobbing or batch manufacture using a functional layout will have a fair proportion of its working 'capital' tied up in work-in-progress.

3. Stock control, largely dependent on the efficiency of paper system and stores, which aims to guide decision-making on stocking and ordering policy.
4. Distribution of material costs; this is generally revealed by the so-called Pareto or 'ABC' analysis. This method of analysis directs attention to significant cost areas and nearly always shows that a small proportion of items in stock accounts for a large part of total stock costs: it is these items which require effective control. A typical 'ABC' curve is shown in Fig. 5.2.

Throughput materials are broadly found in three areas: raw materials, work-in-progress and finished parts stores. From a planning standpoint all these materials can be classified as either completely special to a particular order or as common to many orders. The first group tend to be expensive and are only ordered to meet specific customer requirements: they are the 'A' items in the 'ABC' analysis shown in Fig. 5.2. Inventory, wherever it exists, also serves the purpose of acting as a buffer between a fluctuating customer demand and the manufacturing system. In technical terms, stock is said to decouple successive manufacturing operations in the production and distribution system. But of course, while inventory has a positive effect on the utilisation of facilities, it also involves the tying-up of capital. Furthermore, the work-in-progress type of stock in particular represents queues of work inevitably increasing throughput time. Therefore, any stock control policy, as indeed the design of the overall production control scheme, should first examine the nature of the manufacturing system.

Apart from these more fundamental aspects of inventory planning, it is essential to decide upon those materials only to be ordered strictly according to customer demand, and those which can be stocked in anticipation of orders. The important factors which will help determine which materials to stock are:

1. The unit cost.
2. Probability of repeat orders and average demand.
3. Possibility of obsolescence.
4. Delivery time and its reliability.

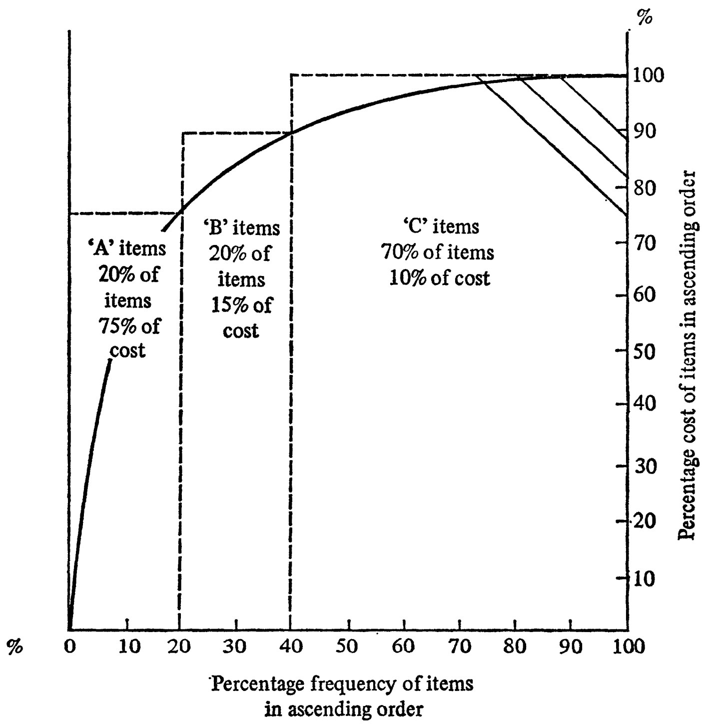


FIG. 5.2. 'ABC' stock analysis

5. Carrying charges, which include storage costs and interest on capital tied up.

If it is decided to stock material, then it is important that, on average, the right amount is available when it is needed. To do this it is usual to establish a reorder level (ROL) for each item. This is usually done taking account of average demand and average delivery time. But in practice, as these two factors are bound to vary about the average, a buffer stock is also added. A typical calculation might appear thus:

1. Average demand per week = 200.
2. Average delivery time = 6 weeks.
   This time should be the time from placing the order to the item being received into the store.

3. Buffer stock, could be based upon the minimum delivery time × average demand = 4 weeks.

Therefore, reorder level = (average demand × average delivery time) plus buffer stock. Using the figures in the example, the ROL would be (200 × 6) + (4 × 200) = 2,000. Theoretically, this should ensure that there are no stock-outs, but in reality a lot will depend upon how much demand and time diverge from the averages. Furthermore, as Burbidge (1971) has noted, it creates the problem of multi-cycle, multi-phase ordering which involves the generation of orders on both suppliers and the factory in differing quantities and at random times. Certainly, production flow analysis combined with standard batch ordering will simplify and speed the passage of work through the system. However, this kind of analysis involves time and probably a change in the part number classification system, but whatever the system adopted, the simple requirement should not be overlooked. This mainly depends upon an easily understood stock record supported by an efficient stores with an accurate and reliable flow of documents whenever material is moved. An example of a stock-control card is shown in Fig. 5.3. This card embodies the ROL system and also compares total stock availability with outstanding customers' orders.

Purchasing

An important part of inventory planning is purchasing. Like the sales department, purchasing is a link with the outside world, in this case the suppliers. It is a function which needs objectives within a clearly defined inventory policy, some of which have already been discussed. In addition, attention should be given to:

1. Discount policy – the aim to pay all accounts in time to get discounts.
2. A systematic procedure for checking invoices.
3. Clearly defined quality standards specified by the design department.
4. An effective system of expediting outstanding orders.
5. The need for a regular evaluation of suppliers in terms of price, delivery and quality.
6. Purchasing research to bring attention to new materials,

Part No. : †2363 – 0404
Description : Brass screw
Drawing No. : 2363 – 0404
Account No. : 2363 – 0404

Delivery time : 6 weeks
Price each : 42p
Unit of quantity : units
Average demand : 200 per week

Reorder level : 2,000
Buffer stock : 800
*Reorder quantity : 2500

† A 'Brisch' type classification system.

1	2	3	4	5	6	7	8	9
Date	Order No's.	Issues	Receipts	Orders outstanding (works or suppliers)	Physical stock	Customers outstanding orders	Free balance	Usage to date
					–3 + 4⊛		+ (5 + 6) –7	+ 3
1/1/72	B/fwd			2500	800	600	2700	–
1/1/72	x123		2500	–	3300			
3/1/72	A456	180			·3120	420		180
4/1/72	A890					620	2500	

Obsolescence factor = Average physical stock ÷ Total usage over control period.

* Based upon quantity to suppliers discount, could be a standard batch quantity.

⊛ Refers to column numbers and shows method of calculation

FIG. 5.3. Stock control card

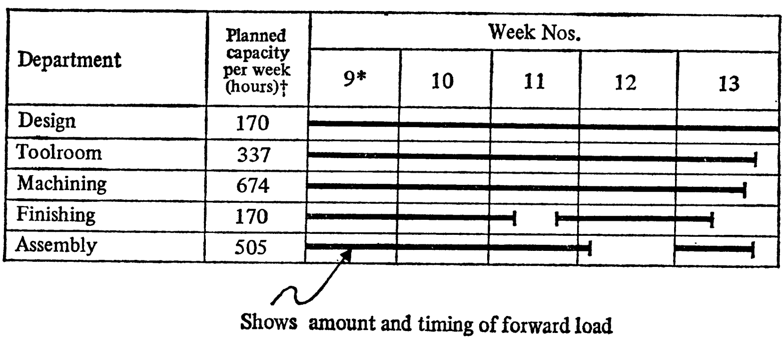
components or other information that will reduce costs or improve the product.

7. Costs of running the purchasing department.

These seven points, in addition to being an important part of inventory planning, can also be used as part of an MBO (management by objectives) system for purchasing.

Production Capacity

Another important part of production planning is concerned with inserting new orders into the existing manufacturing load. This task will not only include plant but also design, technical planning and



† Maximum hours at 90 per cent efficiency
* The scale for each row or column represents planned capacity for appropriate department

FIG. 5.4. Forward load programme

the toolroom. Ideally, the load on these facilities should be maintained on a time basis, but some kind of information should be kept, however crudely, on the extent to which capacity is already committed. An outline forward load programme for a company engaged in machining, finishing and assembly is shown in Fig. 5.4. This shows that the design department is fully loaded up to week 13 with the toolroom in nearly the same position. The effectiveness of load programmes of this kind requires attention to three problems:

1. The accuracy of the unit of measurement. In the example the load is expressed in hours.

2. The determination of the planned capacity available. Clearly it would be inadvisable to plan on the maximum available, but should it be 90 per cent as indicated, or something else?
3. Determining when the capacity will be required. This will depend on whether other orders are completed as planned. In practice, factors such as tools, materials, customer and production problems all disrupt the programme. Nevertheless, this should not deter the manager, whose task is to gain control over these variables.

SCHEDULING

Pre-production planning is concerned with making preparations before the actual manufacturing process commences; scheduling is concerned with the correct sequencing of live work through the works. So that this function can be carried out efficiently there are two important requirements:

1. Reliable information on the location and state of all work-in-progress.
2. The determination of an understandable and effective scheduling rule. This rule is bound to be influenced by the results of pre-production planning; indeed, this activity creates a kind of tidal wave which is difficult to redirect once started. This is why any scheduling procedure, based upon as much information as can be afforded, should take account of the day-to-day changes in production circumstances.

In so far as costs will allow, work-in-progress information should include the following details:

1. The amount of work at each plant group expressed in labour hours; this then provides the length of the queue.
2. The location of each individual works order, together with the sequence, operation times and delivery date.

The updating of this kind of information necessitates a simple paperwork system which signals job movement, and well-defined work-in-progress areas. In the light of these facts, it should be possible to develop a rule to decide upon work priority at each manufacturing stage. Gere (1966) suggests that the effectiveness of a scheduling rule should be measured by how it achieves a particular objective. The objective will no doubt vary from company to company, but a possible one could be to meet a particular delivery performance combined with certain plant utilisation and work-in-progress figures. In a simulated exercise, Bulkin (1966) showed that delivery performance was improved when the 'minimum slack time per operation' rule was used. Slack time per operation is calculated thus: time to delivery date minus remaining processing time to completion ÷ number of operations to completion. In Chapter 3, six other factors were listed which were used in a forging factory. For reference, these factors, with others proposed by Gere (1966) and Bulkin (1966), are:

1. Week when job is due.
2. Utilisation of plant.
3. Output requirements.
4. Requirements of other operations.
5. Time to complete batch on remaining operations.
6. Piecework requirements of operations.
7. Slack time per operator.
8. Total slack time.
9. First come, first served.
10. Work-in-progress value up to present operation and estimated value to completion.
11. Random.

The development of an appropriate scheduling rule will necessitate first deciding what is to be achieved and then, by trial and error or simulation, determining which rule best meets this aim.

CONTROLS

If it is decided to monitor the efficiency of the production process, then a control system is essential. To be effective, control information should cause appropriate action to be taken and should therefore:

1. Be simple and understood by whoever has to use it.
2. Direct attention to where essential action should be taken.
3. Present information which is up to date, relevant and accurate enough to achieve adequate control.

No. 1 OUTPUT, RECEIPTS, WAGES, PURCHASES, INVENTORY, ORDER BOOK

1 *Month*	2 *Receipts* £	3 *Output* £	4 *Order book* £	5 *Months' works* 4÷3* (Av.)†	6 *Production wages* £ 6÷2*	7 *Purchases* £ 7÷2*	8 *Inventory* £	9 *Inventory turnover* (12×3)‡÷7*
Budget	75,000	75,000	150,000	2	15,000 20%	25,000 33%	225,000 3 months	4
January 1972	78,000	74,000	172,000	2·3	16,500 22%	28,000 38%	228,000	3·9
February 1972	79,000	76,000	175,000	2·3	15,600 20·5%	26,500 34·5%	226,500	3·5

No. 2 ORDER PATTERN

Month	*% Distribution by order size*					*% Product groups*			
	1–50	51–100	101–250	251–1000	1001 >	A	B	C	D
January 1972	30	40	20	5	5	70	20	8	2
February 1972	34	41	16	4	5	66	22	8	3

No. 3

WORK LOAD

Month	*Pre-production planning*						*Manufacturing*					
	Design		*Technical planning*		*Production continuity*		*Tool room*		*First operations*		*Last operations*	
	No. of jobs	*Weeks' load*	*No. of jobs*	*Weeks' load*	*No. of jobs*	*Weeks' load*	*No. of jobs*	*Weeks' load*	*No. of jobs*	*Weeks' load*	*No. of jobs*	*Weeks' load*
January 1972	28	5	12	2	8	1·5	140	4	140	3	210	2
February 1972	27	4·5	10	1·6	5	1·2	142	4	235	3	230	1·5

No. 4

PROGRAMME ACHIEVEMENT

1	2	3	4	5			*Overdue orders*	
Month	*Orders programmed*	*Programmed dispatches*	*Other dispatches*	*Total dispatches*	*Programme achievement* 3÷2*	*Output achievement* 5÷2*	*Up to 2 weeks*	*Over 2 weeks*
January 1972	240	190	30	220	80%	91%	70	10
February 1972	250	220	20	240	87%	95%	60	30

* Refers to column numbers.
† Average monthly output.
‡ To arrive at projected 12 months' output.

FIG. 5.5. Overall production management control system

From a production planning and control viewpoint, there are two broad aspects which require attention. One might be called control at the macro or overall works organisation level, and the other at the micro or individual works order level. What is to be included at each level will, of course, vary according to company requirements but a suggested format might appear thus:

Macro Level

1. Order pattern, showing order size, distribution and changes in product mix.
2. Size of order book, preferably expressed in terms of number of weeks' work both for the works as a whole and for major plant groups.
3. Size of work load on service functions, e.g. design, technical planning, toolroom and production control.
4. Order receipts, order output, production wages, throughput materials, purchases and inventory.
5. Programme achievement showing both delivery performance and output performance.

A control statement including these points is illustrated in Fig. 5.5.

Micro Level

1. Acknowledgement to customer.
2. Completion of design information.
3. Completion of operating planning.
4. Completion of tooling.
5. Delivery of materials.
6. Issue of production control documents to instigate the commencement of manufacture.
7. Completion of first and last operation.
8. Dispatches to customer.

Fig. 5.6 is a suggested record which monitors progress at each of these eight control points. Just as with stock control records, wherever appropriate, to facilitate comparison, figures are expressed cumulatively. This can create clerical problems but is an essential requirement for effective control.

Clerical Aids

Although a production control system is much more than just pieces of paper, once the objectives and policies have been determined,

Control point	*Details*	*Programme*				
	General description of order, including order number, quantity, customer, part number, date ordered and delivery requested					
1.	Acknowledgement of delivery date	*Target date* 7/1/1972		*Actual date* 10/1/1972		
		Programme date		*Actual date*		
2.	Design information	11/2/1972		22/2/1972		
3.	Operation planning	1/3/1972		16/3/1972		
4.	Tooling	5/4/1972		19/4/1972		
			April	May	June	July
5.	Material deliveries	Programme	250	250	250	250
		Cum. prog.	250	500	750	1,000
		Act. del.	100	300	250	350
		Cum. del.	100	400	650	1,000
6.	Issue of production control documents	Programme	10/4/72	8/5/72	5/6/72	3/7/72
		Actual	21/4/72	9/5/72	5/6/72	3/7/72
7.	(*a*) Completion of first operation	Programme	250	250	250	250
		Cum. prog.	250	500	500	500
		Actual	100	300	250	350
		Cum. actual	100	400	650	1,000
	(*b*) Completion of last operation	Programme	250	250	250	250
		Cum. prog.	250	500	750	1,000
		Actual	80	290	265	355
		Cum. actual	80	370	635	990
8.	Deliveries	Programme		500	250	250
		Cum. prog.		500	750	1,000
		Actual		370	265	355
		Cum. actual		370	635	990

FIG. 5.6. Outline works order record

efficient clerical aids are no doubt important. It is essential to remember that a paperwork system does not of itself control manufacture. Furthermore, if the points already looked at are not dealt with, a sophisticated document procedure can make matters worse. Having said that, the general aids that can be employed are as follows:

Office aid	*Range available*
1. Transcription	Handwriting to electronic typewriter

2. Copying	Carbon paper to xerography
3. Calculating and accounting	Ready reckoner to computers
4. Communication and transport	Verbal and walking to pneumatic tubing
5. Sorting	Edge-punched cards to computers
6. Filing	Simple filing boxes to microfilm.

SUMMARY

In this chapter the intention has been to show that production planning and control is a significant function in any works organisation. It should be constantly monitoring the reactions between external demand and the manufacturing system to see how extensively changes are causing any deterioration in performance. As a

Question	Score Good 3	 Satisfactory 2	 Poor 1
1. What kind of controls exist on: (*a*) Size of order book (*b*) Productive wages (*c*) Purchases (*d*) Inventory (*e*) Order pattern (*f*) Work load on main facilities (*g*) Programme achievements (*h*) Design time (*j*) Operator planning time (*k*) Tooling time (*l*) Material delivery time (*m*) Main manufacturing stages 2. Are you aware of the actual decision rules used in scheduling? 3. How reliable are the measurements used on controls 1(*a*) to 1(*m*)? 4. Cost of operating production control department			
Total score (maximum 15 × 3 = 45)			

FIG. 5.7. Production control audit

result of this surveillance, appropriate action can be taken. Another important task is to pre-plan facilities so that the production process can take place as smoothly as possible, but bearing in mind that production management will never be a smooth ride. Next, it was shown that the scheduling of work through the system is a complex activity and while some objective rules are necessary, natural flair should not be frustrated by a rigid system. Indeed, the previously mentioned work of Gere (1966) has shown that 'rule of thumb' can be built into a scheduling procedure. Finally, the nature of control has been explored. Again, quantitative feedback is needed but in the many jobbing or batch companies leg-work provided by the progress man is still important, provided he is guided by a clear, single-minded policy and does not suffer from the conflict of competing priorities. Production control is at its best when it is simple, flexible, with insistence on essentials and, above all, operated by people who enjoy the fun of it.

If you wish to check the effectiveness of your own set-up, answer the questionnaire shown on Fig. 5.7, not forgetting that the cost of operating a service function, like production control, also needs full attention. In making your score, determine if the control exists at all, and if it does, is it used on a regular basis and does it stimulate action?

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6 | Maintenance and Inspection

OBJECTIVES OF MAINTENANCE

With the increasing capital sums being invested in ever more sophisticated plant, coupled with rising labour costs, it is not surprising that the maintenance function is claiming attention. Not so long ago it was something of a Cinderella activity, until the influence of military and aeronautical practice brought planned maintenance to industrial management's notice. This, like other techniques, was hailed as a kind of universal panacea and the maintenance of almost every piece of equipment that moved was duly planned. Today the situation has changed: a more diagnostic analytical approach is being used. The maintenance of facilities has come to be seen as part of general company objectives. Furthermore, the economics of the problem are being examined before embarking upon any changes. At present, it is generally appreciated that it would be futile to increase maintenance costs from, say, £1,000 to £1,500 if down-time costs in the same period amounted to only £900. As with most problem situations, the first step here should be to collect all the relevant facts.

A survey carried out in 1969 by P.A. Management Consultants for the then Ministry of Technology into 515 firms found that only half of them kept any information on down-time. The report also revealed that some £1,100 million was spent on maintenance in British manufacturing industry and that by simple improvements direct maintenance costs could be reduced by £200–£250 million with savings in lost production of the order of £200–£300 million. Clearly, then, maintenance deserves attention, but first and foremost its objectives need to be clear. One overall objective might be that of sustaining plant availability both in the short term and the long term, while recognising that 100 per cent plant availability all the time is economically unacceptable. Implied in this objective are the two ways which can be used to preserve plant availability. One is by various kinds of maintenance which include planned, preventive and corrective maintenance. The other way is by replacing the plant by more reliable, possibly more competitive plant, less costly to maintain. Both these approaches can be classed as direct maintenance costs, but not forgetting, as previously noted, that these costs need to be constantly related to down-time costs. In other words, the maintenance engineer's function is concerned with minimising the total of his own maintenance costs plus the costs of idle plant. Young (1963), in an interesting paper on the economics of down-time, suggested that the cost of projects that seek to improve product quality, lower manufacturing costs or improve amenities should be kept separate from direct maintenance expenditure.

MAINTENANCE TERMINOLOGY

To hack a straight, clear path across a semantic jungle, it might be useful to clarify the terms in general use:

1. **Facilities** includes all plant, equipment, transport, furniture and buildings which are necessary in the manufacturing process.
2. **Down-time** includes that time when facilities are not available for the manufacturing process owing to maintenance reasons; in this context it does not include down-time caused by waiting for materials, setting up and so on.

The remaining vocabulary has been adapted from the Ministry of Technology's booklet *Planned Maintenance* (1966).

3. **Maintenance** is an activity which aims to sustain the manufacturing facilities to an acceptable standard both in the short and the long term.
4. **Planned maintenance** includes the inspection, repair and replacement of parts on a pre-planned basis. It can either lead to a prevention of failure or correct natural wear and tear.
5. **Preventive maintenance** aims to prevent failures and can be achieved either by planned maintenance or by better design.
6. **Corrective maintenance** rectifies the results of wear and tear. Some kind of advance provisioning of spares and labour will have been allowed for.

7. **Breakdown maintenance** is work carried out after a failure, but like corrective maintenance some provision will have been made for spares and labour.
8. **Emergency maintenance** – or a 'run and bust' policy – deals with unforeseen failures for which no advance provision has been made.
9. **Accessibility** relates to information on the kind of maintenance that can be carried out either when the plant is running or shut down.

MAINTENANCE ECONOMICS

Whenever a facility is not available for production, certain costs will be incurred. These costs can be divided into two interrelated groups. They are connected because they influence each other. Fig. 6.1 illustrates these costs in the form of a balance: if, for example,

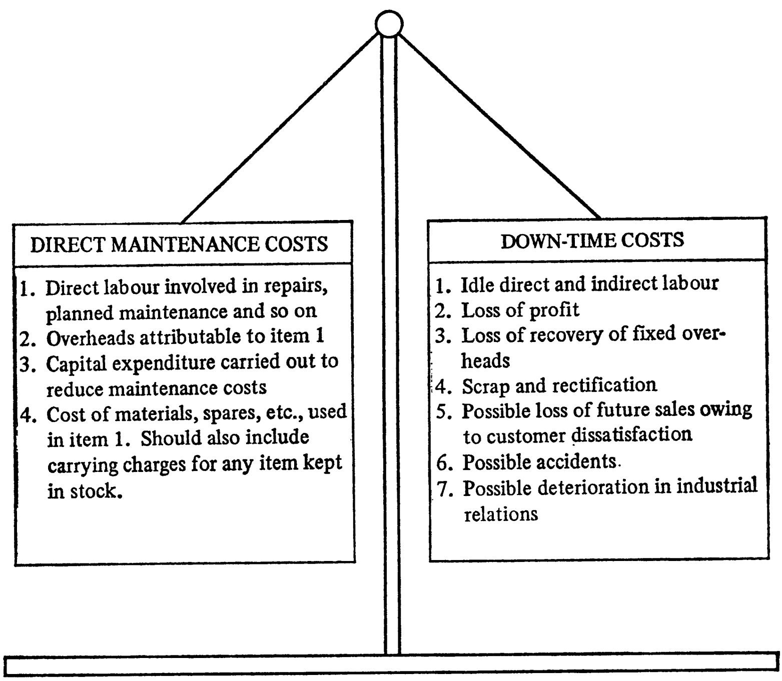


FIG. 6.1. Balance of maintenance costs

down-time costs rise, it should signal attention to the maintenance area. More money may not necessarily have to be spent, but action of some kind is essential.

REDUCING DOWN-TIME

The reduction of down-time is an aim which is bound to claim the attention of the maintenance engineer. However, it is worth remembering that as facilities availability improves, so direct maintenance costs will rise. Hence 100 per cent availability is probably not economically justified. Nevertheless, there are a number of ways in which down-time can be decreased:

1. Increase amount of maintenance labour.
2. Increase the amount of materials and spares which are stocked.
3. Introduce a policy of planned and preventive maintenance.
4. Replace or recondition facilities.
5. Allow for excess capacity in the manufacturing system.
6. Keep a buffer stock of work-in-progress at main production stages.
7. Reduce the misuse of equipment by a programme of operator training.
8. Train maintenance personnel.
9. Use method study to reduce the time taken to carry out maintenance operations.
10. Use some form of work measurement to assess maintenance efficiency.

All these factors could reduce down-time, but some could also improve maintenance efficiency, i.e. more facilities availability for no increase in direct costs.

THE MAINTENANCE SERVICE PROBLEM

A basic problem facing the maintenance department is to decide how much resources, in the form of direct labour, materials and spares, should be provided. On the one hand, if resources are kept to a minimum there is a good chance that facilities will be waiting for service. If resources are increased, facilities will probably not be awaiting services but some resources will be idle. Clearly, what is required is a policy which minimises the two costs shown in Fig. 6.2.

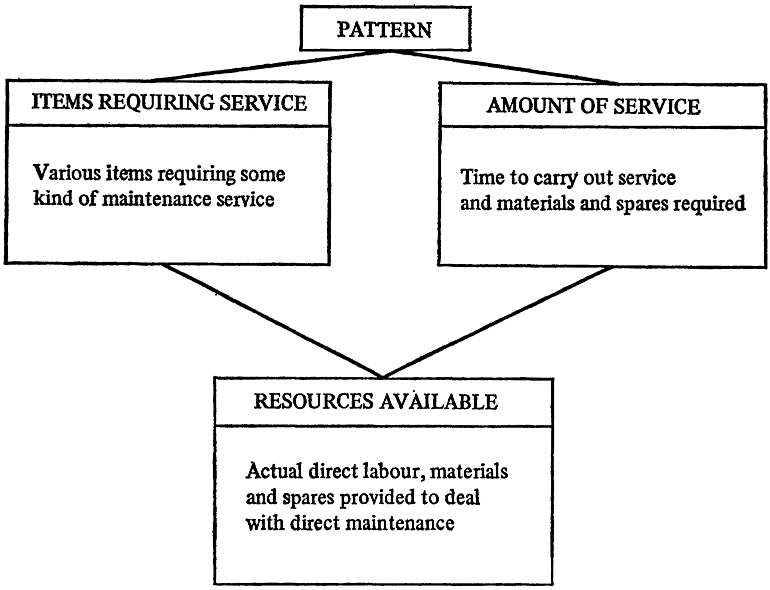


FIG. 6.2. Maintenance service problem

The problem is presented diagrammatically in Fig. 6.3. It is possible to resolve this problem by first ascertaining the pattern of items requiring service and the amount of time such service takes. This can be done by activity sampling. The information obtained makes it possible to determine by simulation techniques the amount of down-time resulting from a given amount of service. Conversely, the extent to which maintenance resources are idle can be revealed. By carrying out further simulations using varying resources (e.g. increased labour), a minimum-cost policy can be evaluated.

MATERIALS AND SPARES

As with production materials, the materials and spares which are used in maintenance departments fall into two groups. Firstly, there are those special to one or two pieces of equipment; such items are often costly and take time to obtain. Secondly, there are the items which are in common use, such as lubricants, nuts, washers and so on, tending to be of low value and with a short to medium delivery

Analysing Different Courses of Action

Basic information obtained:

1. Down-time costs of hydraulic motor — £25 per hour
2. Plant is in operation for eight hours per day
3. Alternative courses of action

Alternative	*Repair time (days)*	*Costs*
(*a*) Run and bust – no spares	7	£350 repair
(*b*) Keep in stock appropriate spare parts	5	£325 repairs £25* spares
(*c*) Keep a spare motor in stock	1½	£60 repairs £1,250* spare motor

* Includes carrying charges

Cost factor	*Alternatives* (*a*) Run and bust	(*b*) Spare parts	(*c*) Spare motor
	£	£	£
1. Spare and materials	nil	25	1,250
2. Repair cost	350	325	60
Total direct maintenance cost	350	350	1,310
3. Down-time costs, i.e. repair time × £25 per day	1,400	1,000	300
Total cost of alternative	1,750	1,350	1,610

FIG. 6.3. Maintenance decision-making

time. The factors which should be considered when deciding whether to stock or purchase as the need arises will of course be dominated by the need to minimise costs. An effective policy can be developed by attention to the following principles:

1. If it is a special item, determine the probability of down-time cost compared with the cost of stocking the part. This kind of problem can be illustrated with an example. A medium-sized company is periodically faced with the failure of a hydraulic motor, an important part in the production process. At the present time the company operates a run-and-bust policy, which may in some circumstances be economical because no spares are kept in stock. The works manager is dissatisfied with

the situation and decides to investigate costs of alternative policies, and also to obtain the relevant costs. This information and a method of analysis are shown in Fig. 6.3. Alternative (*b*) would seem to be the cheapest, but before making a final choice the following additional factors should also be considered:

(*a*) The future of the process.
(*b*) Is there any other way of fulfilling the same purpose?
(*c*) The probability of failure.
(*d*) Can the failure be prevented?
(*e*) Can method study reduce repair time?

This kind of analysis is an example of the diagnostic approach previously mentioned.

2. For common items, control stocks on a reorder level system.
3. Whether materials or spares are kept in a special maintenance or a general store will depend upon local circumstances. In all situations, however, an efficient stores procedure is most important.

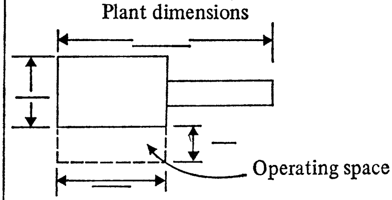
MAINTENANCE INFORMATION

If the maintenance function is to achieve an efficient balance between direct costs and down-time costs, there should be a good information system to obtain facts about the utilisation of resources, such as, for example, plant utilisation. This kind of information can be obtained by four methods: continuous observation, activity sampling, records and instruments, and interviews and general discussions. Although there are many records in use, the following are the more essential ones:

1. Plant records should include basic information such as size, maker and performance details and a maintenance case history showing details of costs and down-time.
2. Maintenance works order which should provide information on the direct maintenance costs of labour and material.
3. Materials and spare parts requisition, an important document if there is to be any control on maintenance inventory.

An outline of these records is shown in Figs. 6.4–6.6. The amount of detail will depend on the various aims of such records. For example, plant records might be divided into mechanical and electrical

BASIC INFORMATION	
Plant type	Plant No.
Supplier	Supplier's Code No.
Department where installed	Purchased price
Net weight in lb/kg	Foundation
Performance details: ______	Installed services:
	Pneumatics ______
Plant dimensions	Hydraulics ______
	Power ______
	Water ______
	Gas ______
	Dust extraction ______



Front of card

Back of card

MAINTENANCE CASE HISTORY				
Details of maintenance	Labour cost £	Material cost £	Total direct cost £	Down-time (hrs)
Totals				

FIG. 6.4. Plant record card

Job Urgency	Maintenance Works Order No. ______
Planned ______ Unplanned ______	Plant No. ______
Importance: high, medium, low } Production ______ Safety ______	Plant description ______

Brief statement of trouble ______

Details of work carried out:

Labour times (hrs)	Costs	
	Labour £	Materials £

Date and Time }	Down time hrs.
Request ______	
Started ______	
Finished ______	

FIG. 6.5. Maintenance works order

Plant No. ______	Maintenance Works Order No. ______
Plant description ______	Requisition No. ______
	Date ______
Planned ______ Unplanned ______	Stock position ______

Quantity	Cost	Cost £

FIG. 6.6. Maintenance material request

equipment with a special document for financial purposes. There may also be economic justification for using a works order system only for the critically significant items of plant.

PLANT ANALYSIS

An efficient maintenance service, which is concerned with minimising costs and improving production flow, requires a knowledge of the characteristics of the plant to be maintained. Above all, it is essential to know which are the critical items of plant, i.e. those items which if not available can appreciably affect output. The condition and maintainability of plant is also required if a realistic policy is to be developed. A form which has been found to be useful for determining the current state of plant is shown in Fig. 6.7. The ten factors used in this analysis are:

1. **Down-time costs per hour.** These should be ascertained using the factors stated in Fig. 6.1.
2. **Percentage importance to output.** This measurement can be used in place of, or in support of, down-time costs. It could be a purely subjective assessment or obtained by estimating the percentage amount of output that would be lost for every hour of down-time.
3. **Percentage utilisation** is an initial analysis, which again could be based upon personal opinion, at least until measurements can be taken. It must be remembered that while utilisation is affected by the kind of maintenance policy pursued, it is also influenced by the product mix, manufacturing system and production planning and control.

Any one of these first three factors will provide an indication of the criticality of the plant to the total earnings objective of the company.

4. **Age,** taken in conjunction with the other three items headed 'Condition', will give an indication of the items' suitability for the production process.
5. **Competitiveness.** The item may have become less competitive because of age or have just become obsolete. Whatever the reason, production economics should influence maintenance policy, particularly for critical items of plant. This item can be

Sheet ____ of ____

Plant No.	Plant description	Criticality			Condition				Maintenance		
		Down-time cost per hr	Percentage importance to output	Percentage utilisation	Age	Competitive-ness	Maintenance cost per annum	Replacement Cost	Maintain-ability	Reliability	Accessibility

FIG. 6.7. Plant analysis chart

measured by comparing the best time that would be taken, using the most up-to-date plant, with the actual times taken at present. On the other hand, a personal judgement is better than nothing – at least for the time being.

6. **Maintenance cost per annum,** obtained from the addition of direct maintenance costs and down-time costs. This is essential information for critical items and, if not available, steps should be taken to obtain it.
7. **Replacement cost.** In order to compare competitiveness two costs should be obtained: one for an exact replacement, the other for the most up-to-date plant available.

The final three factors headed 'Maintenance' are intended to provide information on how easy it has been to maintain the plant in an efficient condition. It is views of this kind which need to be taken into account when it is decided to replace the item.

8. **Maintainability.** This is a term used by Morgan (1963) to cover the relative ease with which a piece of equipment can be kept in a serviceable condition. Included in this measurement would be parts accessibility, internal configuration, use and repair, environment, and the time and maintenance preparation necessary to effect the service required.
9. **Reliability,** another term used by Morgan (1963), is the amount of time the plant or its various parts give productive running time.
10. **Accessibility,** an assessment of the ease of access for both maintenance and operation, is really an evaluation of plant location in terms of configuration and space occupied and whether maintenance can be carried out while the plant is running or only when shut down. Because it will be difficult to use quantitative measurements, a scale ranging from, say, very good through moderate to poor can be used.

It will be seen that the method of analysis suggested embraces sales, production, plant design and maintenance policy. This overall view of maintenance is now described as terotechnology and was outlined in an article in *Target* (1970) as an all-embracing term for 'the installation, commissioning, maintenance, replacement and removal of plant machinery and equipment plus feedback of operation and design information and of related subjects and practices'.

PLANT CHARACTERISTICS

At the present rate of technological advance, built-in devices will soon signal that some part of the plant needs attention and it will also repair itself. While this situation is still some years away, the best aim remains to be more diagnostic in any approach to plant servicing. Indeed, it is probable that scheduled inspections could increase down-time, especially as there is evidence that disturbing some plant at certain periods in its life can be detrimental. Increasingly, what is needed are methods for ascertaining when a piece of equipment needs attention. This is certainly the policy now adopted by Volkswagen. A similar philosophy was suggested in an article in *Maintenance Engineering* (1972) proposing the need for machinery health monitoring through the use of diagnostic instrumentation. Apart from the use of instruments to predict malfunctioning, more use should be made of the knowledge of malfunctioning witnessed by the skilled maintenance operator. His day-to-day observations are just as useful as instruments. Beishon (1968) suggests that the perceptual ability of maintenance crew should be used to spot unusual plant conditions. To start with, it might be worthwhile to get maintenance to record abnormal behaviour for the critical items of plant. A form for this purpose is shown in Fig. 6.8.

MAINTENANCE PROBLEMS

The optimisation of direct costs and down-time costs will present many problems for the maintenance engineer. He is not only faced with the day-to-day technical plant difficulties, but his effectiveness will also depend on how much the maintenance function is integrated with the other related company activities. His outlook will remain narrow unless a terotechnological approach is developed. An outline of likely maintenance problems and a decision-making framework is illustrated in Fig. 6.9.

INSPECTION

Because the subject of quality control and inspection receives detailed attention in a separate book in this series, only those aspects enabling the works organisation to be pulled together will be dealt with. From an economic viewpoint, the inspection function should be considered

Date prepared Sheet of

No.	Plant no.	Description	Abnormal behaviour						Remarks
			Sound	Visual (oil, water, steam,air)	Touch	Instruments	Consumption (electricity gas, air, oil, water, steam)	Performance	

FIG. 6.8. Plant behaviour form

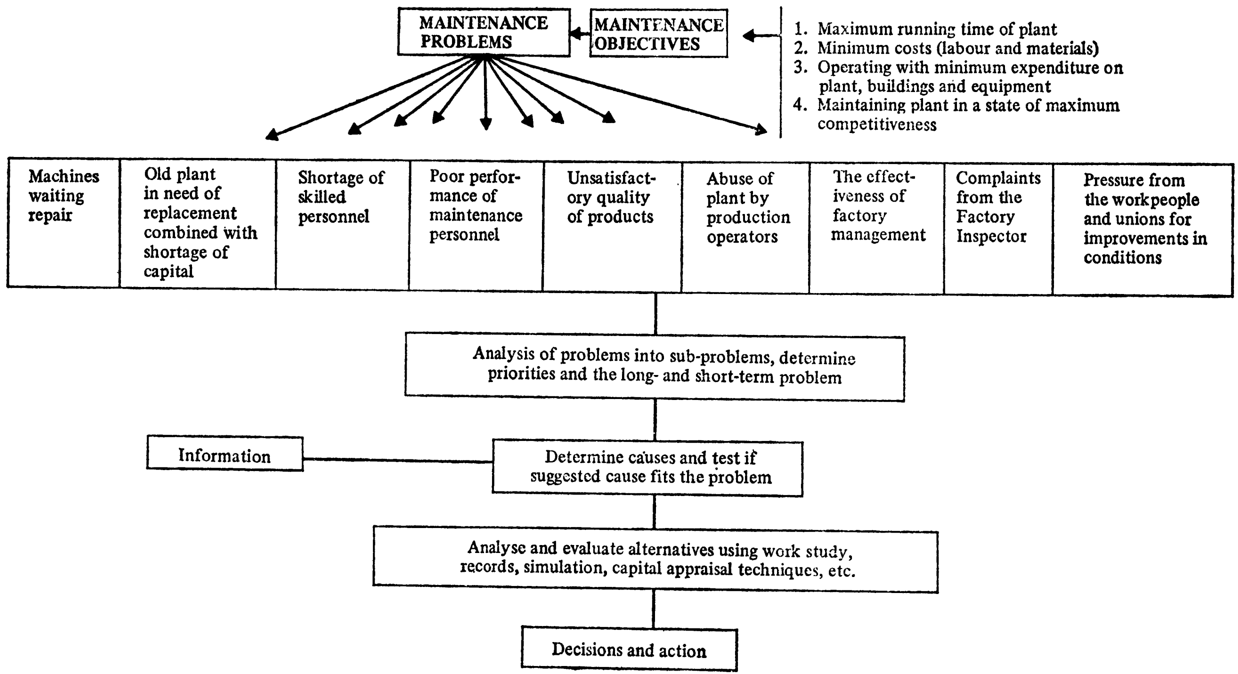


FIG. 6.9. Analysis of maintenance problems and decision-making

similarly to maintenance. Quality standards take on the same meaning as down-time, that is, zero down-time can no more be justified than perfect quality. Thus the need is to decide the standard which will suit our particular market and how much it will cost to achieve it.

While inspection was, and unfortunately in some cases still is, looked upon as an unnecessary overhead, the last few years have seen a change in attitude. The control of product quality and standards of service is now recognised as playing an important part in economical production. Because there are both technical and economic aspects in any quality policy, the following objectives have been divided into these two areas:

Technical Objectives

1. To produce a product and service to a standard which satisfies the company's particular market.
2. To produce a product which is safe, reliable and functions satisfactorily.

Economic Objectives

3. The total direct costs of operating the inspection function are as low as possible consistent with satisfying the technical objectives.
4. Satisfies the requirements of economical production.
5. Does not prevent the company meeting its delivery promises.

THE COST OF QUALITY

Gone are the days when a company could charge any price for its products. Now there is a need to compete not only in price but also on delivery and the general attractiveness of the product. Although quality is important, it would be clearly foolish to give the customer more than he needs or to do it uneconomically. Therefore, an understanding of the costs of quality is important. Quality, like maintenance, costs can be divided into direct and indirect. The former are associated with the costs of operating the inspection function which, as noted, must include an apportionment of the wages of non-inspectors, such as operators and foremen who do this kind of work. Indirect costs are the result of the quality policy and reflect such things as: Is it solely an inspection approach which is concerned with finding failures after they have occurred? Or how much attention is directed towards preventing failures – a quality control approach? The items included under the indirect heading are also influenced by design, the amount of pre-production planning, the

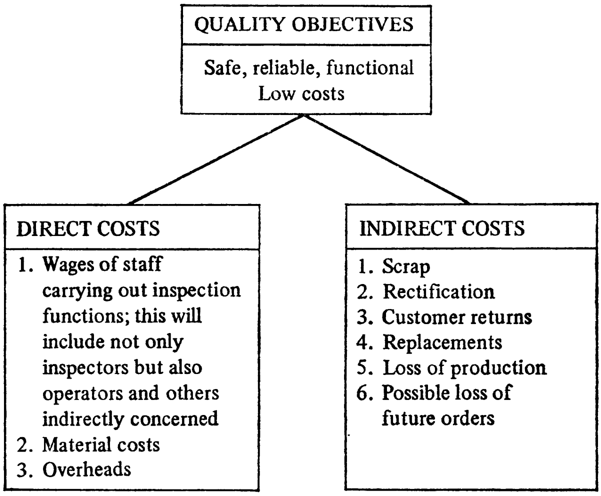


FIG. 6.10. Costs of quality

manufacturing system and the effectiveness of operator training. The items comprising these two divisions of costs are outlined in Fig. 6.10.

THE FACTORS AFFECTING QUALITY

Examination of the factors which can affect quality and in turn a smooth production flow would probably reveal the following:

1. Sales and Design

This concerns the company policy on quality, after-sales service, spares availability and the product mix to be offered. While an organisation's public image is very much influenced by its quality reputation, it is easy to build in more than is required. Furthermore, what is included may be very expensive using existing manufacturing know-how.

2. Suitability of Throughput Materials

Materials can be unsuitable for the production processes and the finished products for two main reasons: firstly, the design department has not clearly specified what are acceptable standards; secondly, it could be due to an ineffective incoming materials inspection.

3. Pre-production Planning

As previously described, this should determine the most suitable manufacturing methods, which include the operation sequence, plant to be used and tools and gauges required. Ideally, if the design and sales requirements can be met by the existing production set-up and the operation layout is correct, the product should flow from operation to operation without any hitches. In practice, of course, this is not so. Among other things, additional operations not included on the layout are found to be necessary and some products require rectification. One of the production man's recurring headaches is not being able to predict the flow of work with any reliability. There are a number of factors which cause this problem, but certainly the amount and quality of pre-production engineering plays an important part. The company engaged in small-quantity manufacture – note this is not necessarily a small company – cannot justify a lot of pre-production engineering with the associated tools and gauges. Implicit in this situation is dependence on the improvisation and manufacturing skill of operators and supervisors.

4. Manufacturing Skill

This is the term which covers the 'know-how' and job knowledge possessed by operators and supervisors. It is now generally accepted that you cannot inspect quality into a product, but the man actually making the part can decide, to a large extent, if it is right first time. Apart from giving the operator the correct materials and tools, a lot also depends upon motivation, value systems and the method of wage payment. A well-designed training programme which includes specific attention to quality standards can also improve manufacturing skill.

5. Work Specifications

Skill, or an experienced worker standard, can be described as producing goods – or for that matter a service – of the required quality and at an expected level of output. In addition to a requirement for relevant training, a precise work specification which details what is to be expected should be provided. Specifications of this kind are generally developed by the work-study function and preferably in conjunction with inspection. They would include staffing, output, quality standards and the duties of the operators concerned. A sample

Process: Light forging hammers, capacity 500 kg

Plant: Two 375 kg hammers
Two 500 kg hammers

Staffing: One senior setter to four hammers
One operator to one hammer
One helper to one hammer

Duties:

Senior setter
Check and clean tools
Obtain drawings
Pre-heat tools to prescribed temperature
Set tools
Supervise that the 'first' off is to drawing
Agree 'first' off with inspection
General maintenance of hammers
Patrol section

Operator
Operate hammer
Produce stampings according to standard times
Lubricate tools
Maintain cleanliness of lubricant
Check forgings at specified frequency
Remove tools

Helper
Load furnace with forging material
Feed operator with heated material
Clean hammer and surrounding area

FIG. 6.11. Work specification

work specification for a company engaged in the production of forgings is described in Fig. 6.11. While this specification concerns a particular industry, the concept is relevant to any organisation – either those producing goods or providing a service.

6. Quality Standards

This, possibly the most important part of inspection, receives insufficient attention. After all, any kind of control is only possible when measurable standards have been set, agreed and are understood by all concerned. Quality standards are generally divided into two groups. There are firstly variables or objective standards which are capable of measurement generally by instruments or gauges. They should present little difficulty because different inspectors will arrive at similar results. The second class are called variables or subjective standards. Examples would be: the jam in the cake must be red, the chocolates are to be smooth or the surface must be scratch-free. Because this kind of inspection relies on judgement and forms a large part of the inspection function, it presents the most difficult problem. However, Seabourne (1964) has demonstrated that it is not insurmountable. Furthermore, the technique of fault analysis developed by Seymour (1966) will also be found to be a useful aid in developing workable standards.

SUMMARY

The intention in this chapter has been to show the part played by the maintenance and inspection functions in the flow of production. An indiscriminate application of management techniques such as planned maintenance or statistical quality control is unhelpful. Rather, the plea is to take an analytical view of the situation by the use of relevant facts. Recognising that the reduction of down-time and improvement in quality standards can cost money, the way resources are directed into these two areas could perhaps be changed leading to better results with even a saving in costs.

It has been mentioned in earlier chapters that departments such as maintenance and inspection occupy a functional or advisory position in the works organisation. But whatever the realities are, the functions certainly need to be integrated into the total company policy; furthermore, how they can influence work flow needs to be appreciated. Factors such as the manufacturing system, the operation layout and quality standards have been shown to be very much interrelated and play an important part in the total earnings ability of the company.

The next three chapters will endeavour to draw the strings together by the examination of three things: measuring performance, problem areas and the introduction of change.

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7 | Production Evaluation

ORGANISATIONAL PERFORMANCE

Whatever the kind of organisation, be it making products or providing a service, it is bound to be concerned with its performance. After all, if an organisation, by definition, is where people work together to achieve some objective, it follows that some yardsticks are necessary by which we can judge whether the objective has been achieved. In general terms all organisations are input/output systems. Some would argue that service bodies, such as for example local government departments, do not have any output. While it may be more difficult to measure than, say, a company producing washing-machines, nevertheless there is an output. With the growth that is taking place in the non-manufacturing sector we can expect to see more attention given to performance measurements in organisations such as hospitals, universities, central and local government departments. This is not to suggest that the performance measurements in manufacturing industry do not require as much attention; wherever inputs are being converted into some kind of output, then some assessment of how well objectives have been reached is essential.

Against a background of technical, social and economic change we are faced with the problem of what objectives to set ourselves. Technical change will no doubt continue to force us to be continually altering our product mix and the materials used in the conversion process, and to introduce new production methods. On the economic front the problems of inflation and all the consequent pressures on wages have still to be dealt with. Conflicting with inflation and associated growth is the possible movement towards less growth. Galbraith (1970) makes the provocative suggestion that what is wanted is less consumption and more enjoyment from a slower rate of growth. Possibly, with the growing concern about dwindling resources and in favour of a less polluted environment, the anti-growth philosphy could well be engaging management's attention by the mid-1970s. The last factor to influence our objective setting is the subtle social changes which have been going on for the past decade or so. Perhaps industrial democracy is not the answer to our industrial relations problem, yet there is little doubt that people at work seek more satisfaction from their jobs and more say about their immediate work environment. All this suggests the need for a more comprehensive view of our set-ups and for more involvement in what is being called 'organisational development'.

OBJECTIVE SETTING

The far-reaching changes taking place will compel future planning to allow for their implications. The changes will make industrial life no less complicated – and at times maddeningly frustrating – and will also increase the importance of thinking ahead and clarifying objectives. Understandably, therefore, objective setting has received a great deal of attention from writers and businessmen. Drucker (1963) warns us against the danger of trying to seek one aim because it may divert our attention from other, equally important areas of activity. If, however, we consider the organisation as an input/output conversion system, then Martin's (1970) concept of maximising total earnings is a useful overall objective. Apart from its value as a measurement of total systems productivity, it has relevance to value-added tax. Furthermore, as will be shown later, total earnings may be a more socially acceptable way of presenting financial information, particularly to trade unionists. A primary objective of the works organisation is indisputably bound up with adding as much value as possible to its throughput materials. The previously mentioned work by Drucker (1963) lists the following eight areas where objectives of performance and results have to be set:

1. Market standing.
2. Innovation.
3. Productivity.
4. Physical and financial resources.
5. Profitability.

6. Manager performance and development.
7. Worker performance and attitude.
8. Public responsibility.

All these areas, but particularly items 6 and 7, contribute to total earnings maximisation. In a later address, Drucker (1972) talked about the importance of managerial performance and the need to develop objectives to suit the unique requirements of each organisation.

In order that suitable aims and objectives can be set, we first require information about what our position is now. On the basis of this we can define our future targets and set up controls to monitor the extent of our achievement. But there must be a will to improve, and this can only come from managers and all other employees being committed to organisational objectives. We shall be returning to the subject of objective setting in the last chapter.

EFFICIENCY, EFFECTIVENESS AND OBJECTIVES

It will be recalled that in Chapter 1 it was stated that, although the words are used as if they were the same thing, efficiency, productivity and effectiveness are somewhat different. Efficiency, at one level of the organisation, may be viewed as the degree to which facilities are being usefully employed. For example, if a particular item of plant has a maximum feasible availability of 36 hours and the actual time spent on truly productive work is 18 hours, then plant **efficiency** is 50 per cent. We could also measure **effectiveness** in this example by comparing the maximum feasible hours with maximum nominal hours that the plant could be available. While **productivity** is also a measure of efficiency, Martin (1970) has broadened it to include how well an organisation achieves its primary objective – in this case the maximisation of total earnings. Clearly, generating income in these terms must play a significant part in the maintenance of any business. Martin (1968) sees the acid test of a company as not when it has failed to make a profit but when it is no longer able to pay the wages and salaries of its personnel. This is not to suggest that profit is not important – of course it is; however, we need to place in in the general context of the total operation and not let the tail wag the dog.

In contrast to efficiency and productivity, the concept of **effective-**

ness should be constantly making the company aware of its potential. It is somewhat like a cost reduction philosophy which acts as a challenge to standards. The Anglo-American Productivity Report (1950) on productivity measurement mentions a similar idea with the Joseph Lucas 'technical index'. This productivity index is defined as:

$$\frac{\text{Objective standard time}}{\text{Current actual time}} \times 100$$

The objective standard time would reflect the best-known world practice. Apart from this being a good measurement of effectiveness, it should also stimulate managements to keep themselves informed on developments which affect them.

Faraday (1971) in his work defines productivity as

$$\frac{\text{Prescribed output}}{\text{Input of manpower, materials and capital equipment}}$$

The word 'prescribed' is important because it implies a predetermined objective. From this basic productivity measurement of output/input a total productivity measure (TPM) is developed which when used for comparison with a base year also provides a total productivity index (TPI).

OVERALL PRODUCTIVITY MEASUREMENT

To arrive at an overall or macro level of productivity, an acceptable measure of output is required. Perhaps the most popular one is sales value expressed in various forms, such as £, tons, units and so on. Apart from the difficulty of comparison, sales value suffers from another disability. It includes, in the form of purchased materials, outputs from outside sources. Gilchrist (1971) proposes added value as a more suitable output measurement. His use of added value is similar to that of the economists and at the national level is equal to gross value added or net national product, i.e. the difference between sales value and total purchases. Since Martin (1970) has developed a number of secondary productivity indices, the total earnings concept, i.e. the difference between sales value and purchase of throughput

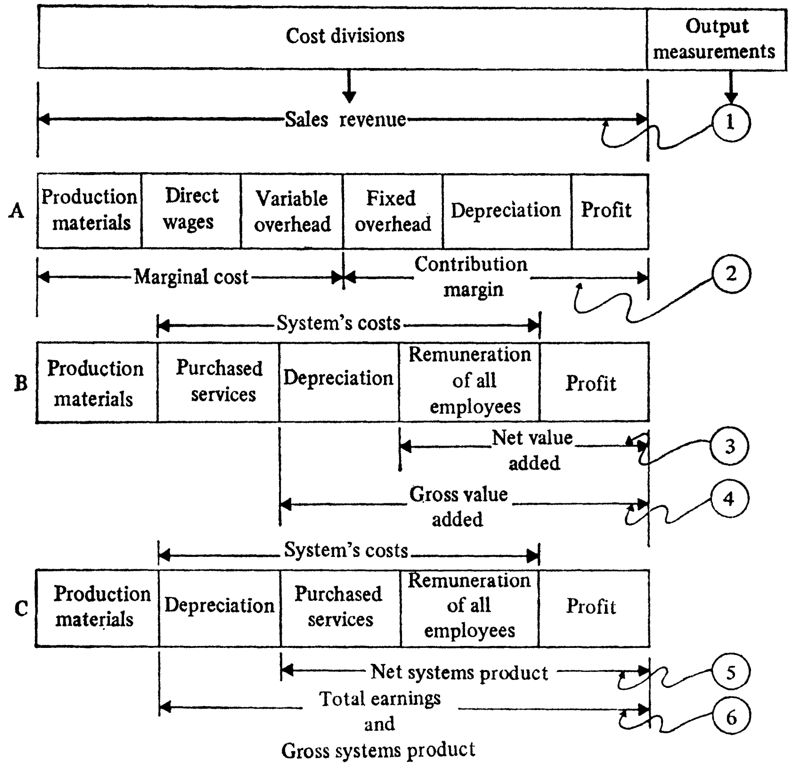

FIG. 7.1. Output measurements

Notes:

1. Sales revenue is the msot usual method of measuring output; in service organisations with no throughput materials, sales revenue equals total earnings.
2. Contribution margin is the accountant's rough equivalent of added value.
3. Net value added is used by economists to measure national output.
4. Gross value added is the economist's version of added value and each company's direct contribution to the gross national product.
5. Net systems product is also used by economists and equates to net national product.
6. Total earnings, the concept developed by Professor H. W. Martin, is the company equivalent of gross national product.

materials, will, as previously mentioned, be used as a primary output measurement. To facilitate comparison, Fig. 7.1 shows the relation ship between total earnings and accounting, economic and government terminology. Although gross value added is a useful output measure, the way throughput productive materials are converted is what most influences a company's total earnings.

Having presented the case for total earnings as an output measurement, we can now proceed to outline the productivity indices developed by Martin (1970). If maximising total earnings is an important primary company objective, then it follows that it is also necessary to maximise the rate of total earnings output (T) per unit of operating cost (C). The primary total earnings productivity index (E_t) can therefore be stated as T/C. Similarly, the rate of profit generation (P) is given by a secondary index P/C.

BASIC PRODUCTION INDICES

Any organisation which proposes to maximise its total earnings will be concerned with aiming to spend as many of its available hours as possible on productive work. For the manufacturing concern, truly productive work is when throughput materials are actually changed in some way. Similarly, in a service organisation, it would be when its particular 'output' is achieving its primary objective. Continuing to use the methods which form part of productivity costing and total earnings, the systems, time and associated costs are illustrated in Fig. 7.2. This includes a number of significant time and cost concepts which are now listed with a brief explanation:

1. C_e is the truly productive work cost and represents the time when throughput materials are being changed in some way. Bahirit (1970) reporting on some research into this subject, showed that only some 30 to 45 per cent of an operator's time was spent on productive work.
2. C_n, which is classed as non-productive time, includes such ancillary work as setting up and unsetting, an item which some would argue is productive. But this is not important; what is important is that we segregate it from added-value time.
3. C_d is product processing costs which are made up of the fixed costs C_f and the variable costs C_v.
4. C_v comprises direct wages of operators and service costs such as electricity, gas, etc.
5. C_f, which includes the fixed costs, can be apportioned in a number of ways. The productivity costing method suggests that

<table>
<tr><td colspan="3">MAXIMUM FEASIBLE TIME</td></tr>
<tr><td>Productive Work</td><td>Non-productive work</td><td>Idle time</td></tr>
<tr><td>Time when value is really added to throughput materials</td><td>Ancillary work such as setting, unsetting, moving work, etc.</td><td>Awaiting work, facilities and operations are idle</td></tr>
<tr><td colspan="3">TOTAL SYSTEMS COSTS – C_s</td></tr>
<tr><td>Productive work costs
C_e</td><td>Non-productive work costs
C_n</td><td rowspan="3">Idle Facilities costs
C_i</td></tr>
<tr><td colspan="2">Product processing cost
C_d</td></tr>
<tr><td>Variable costs
C_v
(direct wages and services)</td><td>Facilities costs
C_f
(fixed costs apportioned to operating facilities)</td></tr>
</table>

FIG. 7.2. System's time and associated costs

Note: The costs and times are not necessarily in the proportions suggested by the diagram.

they are allocated in proportion to the relative present-day purchase value of each facility.

6. C_t is idle capacity costs and will certainly include facilities costs C_f, but could also involve some direct wages.
7. C_s is the total cost of operating the system, and it is worth noting that in modern socio-industrial conditions this is increasingly becoming an unavoidable or fixed cost. Perhaps the only true avoidable costs are for throughput materials.

Maximum feasible hours is a factor the determination of which should be given senior management attention. In addition to having a direct influence on costing rates, it can also significantly affect utilisation indices. Using this notation, the following basic production indices can now be stated:

1. **Facilities productivity** E_f. Because C_e is truly productive work, C_e/C_d is a measure of effectiveness of the use of facilities, and because C_e is included in C_d it can never exceed 1.
2. **Product productivity** E_d measures the amount of purely pro-

ductive work C_e in terms of total earnings and is expressed as T/C_e.

The previously mentioned research by Bahiri (1970) also revealed that not only was a small proportion of time spent on productive work, but for even less time was plant being operated well within its intended capacity.

WORK-FLOW PERFORMANCE

There are many ways of measuring how well work flows through a production system, but for simplicity the stagnation factor and delivery performance, previously mentioned, should be adequate for this purpose. The first is an indication of delays in the system caused by such things as work-in-progress, rectification work, the manufacturing system and unplanned operations. The second, which is influenced by the first, is also a reflection of the efficiency of production control.

INVENTORY PERFORMANCE

Certain aspects of inventory are felt in work flow to the extent that work-in-progress affects delivery time. But we also want to know how many orders cannot be fulfilled because materials or parts are not available. This could be expressed as a percentage or the number of stock-outs per month. Another productivity characteristic is the rate of stock turnover, but as total earnings (instead of sales revenue) has now been proposed, this index is expressed as the total earnings, T, divided by the total average inventory carried, or T/inventory $= T/I = E_s$.

Finally, product inventory productivity can be determined by dividing total earnings, T, by product processing cost C_d which includes an inventory costing rate C_{inv}. This costing rate C_{inv} is comprised of the product's total material and processing costs multiplied by an appropriate carrying charge for the time the product is in the system. In this way, recognition is given to product work-flow time relative to other products. For example, if processing costs are one-fifth of material costs, the carrying charge is 18 per cent per annum and the product is in the system for two months, then

$$C_{\text{inv}} = M + \tfrac{1}{6}\,(C_f + C_r)\,1 + (\tfrac{1}{6} \times \cdot 18).$$

The complete product inventory productivity index may now be stated thus:

$$\frac{T}{C_f + C_u + C_{\text{inv}}} = \frac{T}{C_d} = E_{td}$$

FACILITIES MAINTENANCE

Although varying in its influence from one company to another, maintenance policy does affect facilities productivity E_f. We clearly require indices that tell us the extent to which direct maintenance is affecting product processing time. Still aiming to keep the measurements to a minimum, there are two that will be sufficient to assist managerial decision-making. The first is to maintain trends on direct and indirect costs, and the second a measurement of maintenance productivity E_m consisting of direct costs C_{dm} divided by indirect costs C_{im}, thus: C_{dm}/C_{im}. This is a ratio which should not exceed 1.

QUALITY PERFORMANCE

As with the maintenance area, there are many ways of assessing a firm's quality performance. Some, for example, use the ratio of scrap and rectification costs to direct wages. In order that we can preserve some degree of uniformity similar measurements to those proposed for maintenance will be used. We should therefore require one on trends in direct and indirect costs and the other on quality productivity E_q. The appropriate index would be C_{dq}/C_{iq} where C_{dq} are direct costs and C_{iq} indirect costs.

PERSONNEL PERFORMANCE

So far the measurements have been purely economic, but as the human factor no doubt overrides everything, we should also have some indications of the effects of our policies on personnel. Although the more important aspects of the human climate are difficult to measure, this should not deter us from trying. Two possible manifestations of employees' reaction to the company, what Fox (1966) calls unorganised conflict, are labour turnover and absenteeism. The indices in general use are:

$$\text{Labour turnover} = \frac{\text{Number of separations during period}}{\text{Average number employed during period}} \times 100$$

$$\text{Lost time percentage} = \frac{\text{Number of working days (or hours) lost}}{\text{Total normal potential working days (or hours)}} \times 100$$

What should also warrant our study are the more intangible areas such as attitudes, and resistance to change. Likert (1967) is more ambitious and is attempting to develop a new kind of human assets accounting system which will tell us if our human resources are appreciating or depreciating. Assessments made by senior executives of companies put the value of their human organisation at three to five times the payroll. Using this as a commencing value, the end-result performance variables used by Likert to measure appreciation or depreciation in human assets are: satisfaction, productivity, innovation and psychological health.

MANAGERIAL PERFORMANCE

In the final analysis the performance of individual managers is what counts. It is they, when everything else has been said, who make the organisation tick. At the same time, measuring their performance is not a straightforward task. For one thing we can never be sure whether performance improvement has been due to other variables. Perhaps the best way of assessing their contribution is through the medium of a job description jointly determined by the manager and his boss. As far as possible this should be expressed in non-descriptive measurable terms on the lines of the example shown on p. 40. The job description should not only include the routine measurable activities, but also those significant innovative factors that increase organisational effectiveness. Out of all the decisions a manager makes in the course of a year, it may only be a small proportion that really carries the company a few steps forward. But it is this activity that

No.	*Description*	*Index*	*Your Company*	*Your Industry*
1.	Total earnings productivity	$T/C = E_t$		
2.	Rate of profit generation	$P/C = E_p$		
3.	Facilities productivity	$C_e/C_d = E_f$		
4.	Product productivity	$T/C_e = E_d$		
5.	Stagnation factor	$\frac{\text{Total of operation times}}{\text{Actual delivery time}}$		
6.	Delivery performance	$\frac{\text{Actual delivery time}}{\text{Planned delivery time}}$		
7.	Stock-outs	The number of times per month orders cannot be completed because of stock shortages		
8.	Inventory turnover	$T/I = E_s$		
9.	Product inventory productivity	$T/C_d = E_{td}$		
10.	Maintenance direct costs trend	Total direct maintenance costs per month on a moving annual total basis*		
11.	Maintenance indirect costs trend	Similar to item 9		
12.	Maintenance productivity	$C_{dm}/C_{im} = E_m$		
13.	Quality direct costs trend	Similar to item 9		
14.	Quality indirect costs trend	Similar to item 9		
15.	Quality productivity	$C_{dq}/C_{iq} = E_q$		
16.	Labour turnover	$\frac{\text{Number of separations during period}}{\text{Average number employed during period}} \times 100$		
17.	Absenteeism	$\frac{\text{Number of working days (in hours) lost}}{\text{Total normal potential working days (in hours)}} \times 100$		

* Moving annual total is obtained by taking the total for base year and then adjusting each month by the amount current month varies from corresponding month in previous year.

FIG. 7.3. Check list of productivity measurements

must be fostered, and ultimately it does not matter if it is done through the medium of job descriptions, as long as it is done.

SUMMARY

It is recognised that there are a number of efficiency measurements that have not been included, particularly the more conventional ratios. These have not been omitted because they are not considered important. At the same time, the number of measurements should be kept to a minimum. The intention has been to examine some new concepts and to show how they can be used to measure the fundamental organisational objective of generating output. The notion of output is fundamental whatever the kind of organisation, be it manufacturing or service, for in both situations inputs are being consumed and turned into some kind of output, however obscure this may be. Space has not permitted a detailed treatment of productivity costing and total earnings techniques, but it is hoped that the ideas presented will stimulate new thinking.

For ease of reference, the productivity measurements have been listed and are shown in Fig. 7.3.

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8 | Problem-Solving

THE NATURE OF ORGANISATIONAL PROBLEMS

Some researchers into organisations have compared them to living organisms and suggest that both organisations and their animal counterparts depend for survival on how well they react to their environment. This is a belief that most of us are probably aware of anyway, but the big question is: how do *we* respond to our changing surroundings in an effective way? Perhaps the fundamental nature of organisational problems is how human beings, with all their frailties, become aware of problems and what they do about it. Both individuals and groups – who comprise companies – are being constantly bombarded by information. Some we respond to and the rest is probably ignored. Even the information that is taken in and processed may help the organisation in its real objective of survival, but if we are honest with ourselves, what we do use sometimes makes the situation worse. Simon (1961) deals with this point in his discussion of rational behaviour. Behaviour is seldom rational because people have only a fragmentary knowledge of the real world, and only meagre information about all possible alternatives. This suggests that human choice in problem situations is more often a subjective stimulus-response activity rather than an objective choice from among alternatives.

All that has been said is not to suggest that we cannot deal with our various problems more objectively. Of course we must try to do so, and in any case subjectivity and natural flair can work, as is evidenced by the number of companies that survive. If, however, as suggested earlier, we are living in times of searching change, we shall soon be facing more problems. Although there are many factors concerned, the recurring industrial relations crises are, no doubt, very much the result of change. The other more significant aspects of our material problems are inflation, people's increased awareness of society through mass communication, and the way the government of the day influences the environment, acting wittingly or unwittingly as the agent of social change.

This examination of the nature of problem-solving would seem to suggest that the following determinants require consideration:

1. The **external environment,** which includes competitors, the community, trade unions, the development of new products, processes and materials, by various agencies and various forms of government intervention.
2. The **internal environment,** which consists of the total manufacturing system, people's job expectations and the actual demands made on them by the organisation, the industrial relations climate, managerial style and the reward system.
3. **Information processing,** embracing everything that is involved in the internal environment reacting with the various external forces. This scanning of the internal and external situation will depend upon human perception of available information. It also includes the complex factors which cause some people to search for more information. Search activity, on the available evidence, would seem to play an influential role in problem-solving. According to the work of Cyert and March (1963), we seek information based very much on our personal expectations, which means that even if we began the search we break off at a point that satisfies us.
4. **Open-ended and closed-ended problems.** Unfortunately most organisational problems are open-ended, that is, the mere act of giving the problem attention most probably changes its nature – either positively or negatively. Furthermore, we all know from experience the novelty of the difficulties facing the manager and the lack of any structure in his problems. There are a few closed-ended problems which can be dealt with in a mechanical way; by and large they include the technical problem which can be dealt with using some kind of scientific procedure.
5. The **value system** is the constellation of intangibles, such as a man's beliefs, standards, hopes, fears and expectations, which affect his perception of problems and of how, if at all, they can

be dealt with. The aggregate value system of all an organisation's participants plays a part in its survival potential. Like everything else in a changing world, individual and corporate value systems are undergoing changes, which must not be overlooked.

A diagram which summarises problem-solving and the organisation is outlined in Fig. 8.1.

PROBLEM ANALYSIS

Over the years, a good deal has been written on methods of analysing problems. Many of them are useful, with the implied reservations already made. We need to remember that different people see situations in various ways and certainly react, or fail to react, with unforeseen responses. With this proviso, a general problem and decision-making framework is illustrated in Fig. 8.2. In practice the five stages are interrelated, one overlapping into the other. It is also worth emphasising that we want effective feedback on the results of any problems and decision-making activity. This should tell us two things: firstly, has the problem been changed at all and, if so, in what way?; secondly, has the experience affected the behaviour of the people concerned? Learning from experience is probably an unconscious process, but those who have the ability to recognise it and to act on it are likely to be successful.

PROBLEM- AND DECISION-MAKING DEFINITIONS

Although there is a lot more to problem-solving and decision-making than a mere definition, some attempt at it may help to direct our understanding of the subject. There are two ways of considering problems. Firstly, we can view them as a deviation from something we desire. This could mean either that an existing situation has become unacceptable or that it might be improved. Secondly, a problem is also a situation where there are alternative courses of action open to us. This second view of problems leads us on to decision-making, which can be defined as any situation where there are a number of courses of action from which we must make a choice. Implicit in this view is that making no decision is also a decision. This

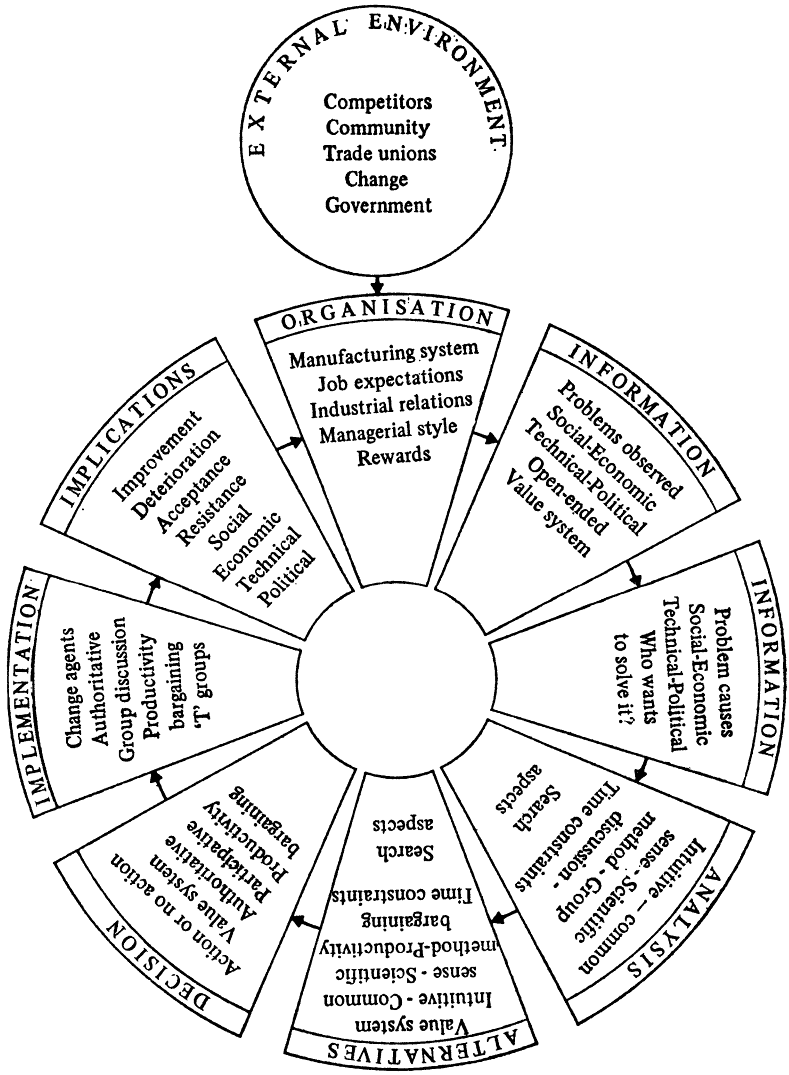

FIG. 8.1. Problem-solving and the organisation

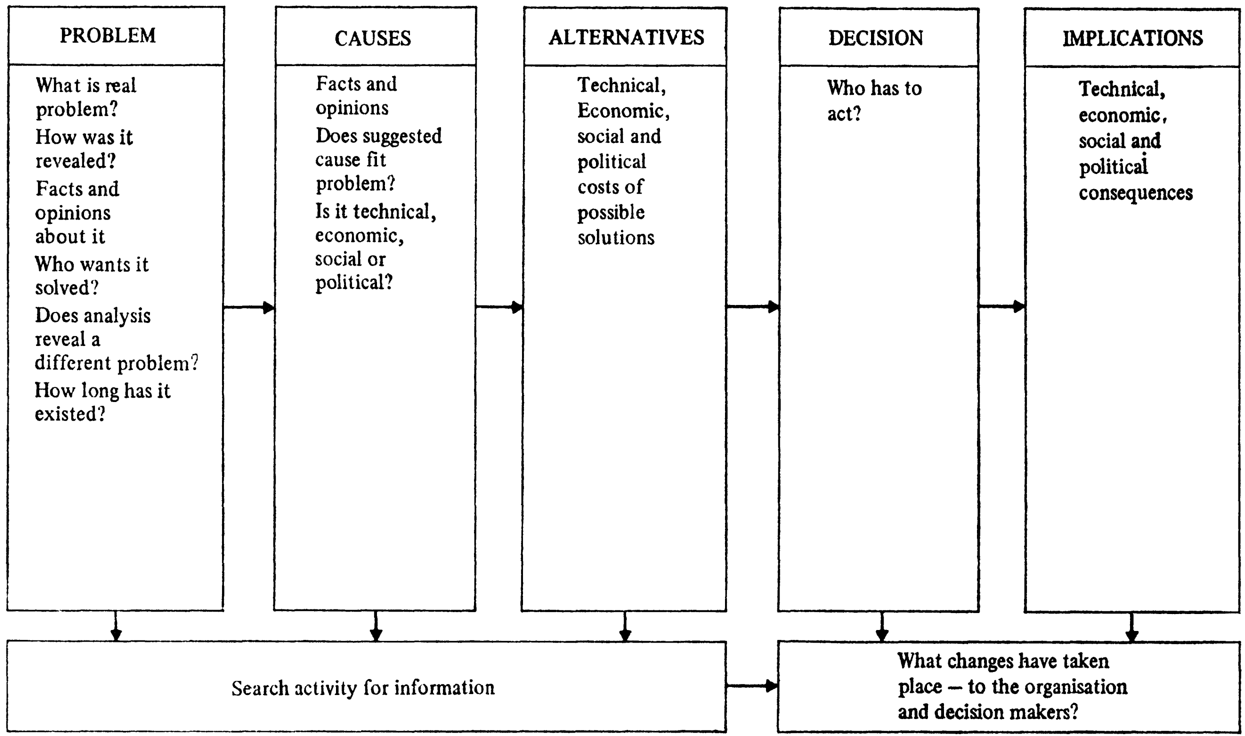

FIG. 8.2. **Problem- and decision-making analysis**

would be true if it was a conscious choice and was not just a question of evading the responsibility of grasping the nettle.

While the deviation principle provides a good insight into problem situations, we are faced with two further difficulties. One is the question of defining the standard from which there has been a deviation. The other concerns how much deviation in fact constitutes a problem. Regrettably, both difficulties keep us firmly in the complex area of human value systems – and all that that entails.

PROBLEM-SOLVING METHODS

Over the years many methods have been proposed for dealing with problems. However, the following list may be appropriate for dealing with the range of organisational difficulties that may be encountered:

1. **Method study** is a long-standing but none the less still useful technique, especially if the more up-to-date approach suggested by Raybould and Minter (1971) is used. Instead of the traditional select, record, examine, develop, install and maintain procedure, they suggest a wider problem-solving method. Their procedure consists of problem definition, finding solutions, choosing a solution and implementation.
2. The analysis of the subject made by Adair (1971) offers an interesting amalgam of various thoughts on the subject. He divides problem-solving into three interrelated areas. Firstly, analysis is the process of breaking the problem down into its main elements. The second area concerns the idea of synthesising which involves reassembling the results of analysis into a more effective 'solution'. This demands the use of creative thinking, which is an important ingredient in problem-solving. Finally, valuing is the way in which our beliefs, standards, and so on influence our whole treatment of the problem.
3. In his searching work on management education, Revans (1971) includes problem-solving as part of an integrated action-orientated programme for both manager and organisational development. The programme involves a manager spending a number of weeks in a different organisation to act as a kind of catalyst for some problem in the host company. The learning

model is divided into three categories: alpha, beta and gamma. The alpha stage is the more rational aspect and is concerned with collecting information and gaining an understanding of the situation. It includes some valuing, but the aim is to develop a decision strategy. While alpha tends to be a rational thinking process, beta on the other hand is more emotional because it is concerned with action. Finally, system gamma is designed to make the managers aware of the effects of the first two stages on both the situation and the manager.

4. **Group problem-solving** is similar to the approach taken by Revans and recognises that in reality we can only bring about changes in problems by involving the people concerned. Effectiveness in group problem-solving requires attention to three things:
   (*a*) People who have the problem have a better understanding of it and what should be done about it.
   (*b*) The group leader should play the part of catalyst, helping the group to formulate the problem and to develop acceptable solutions.
   (*c*) He needs to be an effective listener and a skilful questioner. Above all, he needs to prevent inquests on the past and to direct the group to the current problem. The aim in group problem-solving should be to seek so-called 'integrated solutions' that meet the total situation, rather than compromises or autocratic impositions.
5. A disciplined method of problem analysis is contained in the work of Kepner and Tregoe (1965). The procedure follows four stages: collect information, find causes, determine most likely cause, select most economical solution. Included in the procedure is a format which requires the development of a problem and cause specification. This is done by asking what is and what is not about the problem from the standpoint of the what, where, when and extent of it.

PROBLEM AREAS

In Chapter 1 it was suggested that organisational problem areas fall into four main areas, namely, people, quality, maintenance and production. In practice, of course, it is unlikely that the difficulty

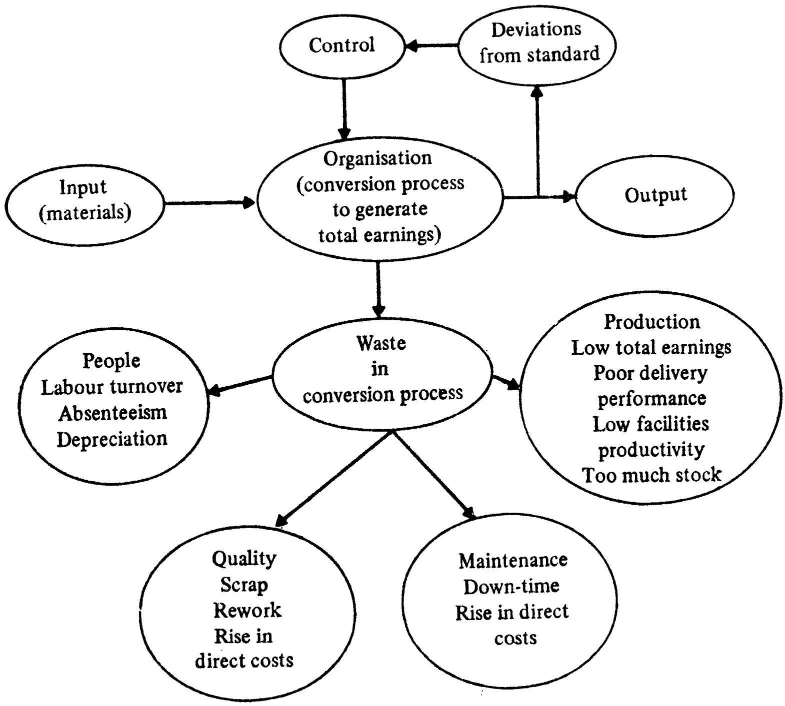

FIG. 8.3. Problem areas

will fall neatly into any one of these categories. It could be a combination of all four but will generally always involve people. As a well-seasoned production manager once said: 'We have no problems here, only when they come through the gates in the morning.' Fig. 8.3 is a diagram showing these areas in relation to the conversion nature of the organisation.

To obtain up-to-date views of works managers on the problems they face, a questionnaire was distributed during 1972 to a small sample of four small-sized companies. With a sample of this size, the results do not represent general opinion but do offer some insight into problem areas and provide a useful tool for studying an organisation. The questionnaire used, with an analysis of the returns, is shown in Fig. 8.4. To ease the burden for the respondent questions 9–16 require close-ended replies. A negative score reflects some dissatisfaction and vice versa for a positive score. On this basis, tools, sup-

No.	*Question*	*Answer*
1.	Type of industry	Light to medium engineering
2.	Basic products	Screws, steel strip, seals and pressings
3.	Total employees	50—160
4.	Total direct operators (engaged on production)	22—40
5.	Total floor area of entire company	† 1130—2800 m²
6.	Direct labour cost (item 4) as a percentage of total annual sales revenue	6·4% to 22%
7.	Sales output per direct operator (i.e. total annual sales divided by item 4)	£4,500 to £12,200

8. The following is a list of statements about matters concerning the efficiency of *your* works organisation. So as to minimise the time required to answer, will you please place a tick against the reply which best describes *your* present, situation. The possible replies are: Strongly Agree (SA), Agree (A), Uncertain (U), Disagree (D), Strongly Disagree (SD). Please only make one reply.

	Score −	Score +	SA	A	U	D	SD
9. Tool availability limits production efficiency	6	2	+1	−2	0	+1	+2*
10. We have no problem with deliveries from suppliers	6	4	+1	+2	0	−1	−2
11. Our production methods require improvement	5	–	−1	−2	0	+1	+2
12. Industrial relations do not affect efficiency	–	4	+1	+2	0	−1	−2
13. Our factory layout is satisfactory	1	4	+1	+2	0	−1	−2
14. Quality dos not affect our productivity	5	–	+1	+2	0	−1	−2
15. Information on all aspects of production is adequate	3	–	+1	+2	0	−1	−2
16. The structure (arrangement of people and functions) of the works organisation is satisfactory	–	4	+2	+2	0	−1	−2

17. In what ways would you like to improve *your* existing works organisation (please write on back of paper)

† Area in m² per direct operator ranges from 51·1 to 56·7.
* Method of scoring: a negative score suggests some dissatisfaction with the item; a positive score, satisfaction.

FIG. 8.4. Works organisation questionnaire

plies, production methods and quality suggest some cause for concern. Question 17 provided an opportunity for the respondent generally to express his views on things he would like to improve in the organisation. The following list is a summary of the replies:

1. People:
   more skilled operators;
   improve quality of labour.
2. Managerial:
   improve quality of management;
   more aggressiveness in searching out problems;
   resolve senior management conflict;
   need continuously to improve organisation;
   provide management succession.
3. Production:
   improve machine utilisation;
   improve materials handling;
   increase customer service;
   improve production control;
   improve production engineering.
4. Cost:
   improve wage-payment system;
   increase cost consciousness.
5. Quality:
   improve quality.

A somewhat similar but more comprehensive approach, developed by the Swedish Employers' Association, is described by Svensson (1971). This analysis consists of four steps: financial survey, check lists, analysis chart and planning.

SUMMARY

It is generally accepted that problem-solving and decision-making occupy a lot of managerial time. Yet inaction until the situation has developed will only make it more difficult to deal with. Therefore, by various human and other devices, we need to be sensitive to information and to search for more if the situation demands it. Problem-solving and decision-making, as Revans (1971) has shown, can be integrated into the management development process. Methods for utilising the results from examining organisations to produce effective change in them will be outlined in the last chapter.

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9 | Improving the Organisation

RESPONDING TO CHANGE

There are many in various walks of industrial life who believe that management's major challenge is how to manage change. This implies that we can either react positively by seeking information about the factors that will affect our particular organisations and dealing with the problems revealed, or alternatively we can wait for events to come banging on our doors – previously referred to as the bush-fire philosophy. Survival, in modern industrial circumstances, really demands the former approach of taking the bull by the horns, in other words managing the situation. Bowlby, in the 1972 E. Percy Edwards Paper, makes the same point when he proposes that the successful business requires positive attention to change. Furthermore, the forces of change need steering and controlling so that the company is reinforced, which in turn should lead to a more productive operation both economically and socially.

Responding to change in an effective way so that it leads to a continuation of the organisation is easier said than done. Countless living species, even long before man began to influence the environment, failed to adapt to change and became extinct, which implies little chance of survival for a complex entity such as an organisation. Many of them will, for various reasons, also go to the wall, as is evidenced by the number of bankruptcies and other failures. Nevertheless, the survival rate can be improved but will require a recognition of the following points:

1. Any organisation is bound to be composed of conflicting economic, technical, social and political beliefs. At least it will be a coalition of differing interests which somehow needs managing.

2. That conflict is an inherent part of organisational life, but can be a healthy sign if it can be dealt with constructively. Furthermore, there needs to be a system that permits the effective ventilation of conflicting interests.
3. Organisations are living in a constant state of inadequate and obscure information.
4. Apart from accelerating technological change, there are deeper social changes at work which will require a reassessment of value systems and attitudes, particularly on the part of management.

INFORMATION ABOUT CHANGE

Effectively dealing with change, like problem-solving, requires a continuous flow of relevant information. In whatever form it exists, an information system is the sensing device to which the organisation responds. There are probably two ways which tell us what is happening in the internal and external environment. One is the formal system which consists of control information and various kinds of consultative machinery. The second is more informal and is the kind of facts, opinions and information which flow in a number of random ways through every organisation. On the basis of both of these broad groups of information, further knowledge may or may not be sought: this is the search activity previously mentioned. Both of these sources are clearly important, but whether the implications contained in the various messages are used to sustain the organisation will depend upon the sensitivity of the people concerned. The manager, with his invisible sensors, who is alive to everything that affects him and his company, is certainly a valuable asset. This is why clearly the most sophisticated control system is useless unless someone does something with it. This is not to say we should take action with everything that passes across our desks; effective information processing also requires skill in selection. The last few years' marked emphasis on management techniques and the behavioural sciences can easily have led us to apply quick cures – a good example of the influence of outside agencies. The same is also true about internal information: we can easily form incorrect views about problems. What, then, is wanted is a simple formal system that tells us the essential facts which affect the business and which can take the form of various documents and the information which is obtained from consultative and other such meetings. The seemingly unimportant information which flows haphazardly and informally should not be overlooked, since next month or next year it could be significant.

The two broad areas on which we need to be kept informed are:

1. Technico-Economic

This kind of information should generally be embodied in the formal control system. But there is also a need to watch for the results of any developments, however obscure, which at the present rate of change could affect us in, say, a year's time. The items to be included in the formal system have been included in previous chapters and can be summarised thus:

(*a*) Trends in order pattern with regard to order size and product mix.
(*b*) Trends in cost distribution relative to throughput materials, direct labour and overheads.
(*c*) Productivity measurements, items 1, 2, 3, 4, 9, 12 and 15 in Fig. 7.3 (see p. 112).
(*d*) Trends in the costs of service functions, particularly production control, maintenance and quality.
(*e*) Changes in the nature of the reward system, with particular regard to the suitability of the various methods of wage payment.
(*f*) Changes in work flow reflected by measurements of the stagnation factor and delivery performance.

At the informal level it might be useful to keep a file of all new developments in products, processes, materials and new organisational approaches which could be significant. For example, the experiments now being made with flexible working hours and job restructuring could soon be common practice. The file should be regularly reviewed at various kinds of meetings. Such meetings of, e.g., consultative and productivity committees not only provide opportunities to discuss the implications of possible changes revealed by the formal and informal systems, but also allow ventilation of problems not disclosed by them. It must be clearly recognised that this two-way information flow will occur only if a receptive environment has been created in a climate wholly dependent on management's attitudes and beliefs.

2. Social

In periods, such as the present, of profound social upheaval, this may manifest itself in destructive industrial conflicts, the harmful effects of which can affect large sections of the community. If, however, one takes an objective, detached view, the situation proves not to be quite so unbearable as might appear. Solutions will not come easily, but then all real human progress has been a long, hard road. The part that management can play should begin by gaining an understanding of the following interrelated aspects of the problem:

(*a*) Improved **education** in both quality and quantity has caused people, particularly the younger generation, to expect more satisfaction from their jobs and to want to participate more in decision-making.

(*b*) **Information** in its various forms, e.g. television, newspapers, company systems, is making people a lot more aware of all aspects of society. In particular, we are coerced and persuaded to buy the materialistic products that are available. At the same time we are also reminded of our place in the wages pecking order. Is it therefore any wonder there is conflict if our pay does not enable us to acquire these products, especially if the wage packet no longer compares with that of the people 'down the road'.

(*c*) **The manufacturing system,** which includes plant, plant layout, manufacturing methods, controls and the organisation. It is all these things that have led to the massive rise in the standard of living during the last hundred years. Contrarily, it is the same technological progress which has removed from work most of the satisfaction that used to be enjoyed by the craftsman. This is why the work of such behavioural scientists as Maslow, Herzberg, Likert and McGregor has taken on such significance. There is also ample evidence to show that power has now shifted to peripheries of organisations, and certainly much of the control over such things as job costs exists on the workshop floor.

(*d*) **Inflation** has been a symptom of post-Second World War economics and is inextricably bound up with full employment, growth and technological advance. If examined in relation to the previous three factors and people's fears about the value of next year's pound note, there is bound to be unrest, to say the least. Governments of all Western economies are wrestling with the problem and prices and income policies, however crude, are being developed. There is also increasing awareness that these changes can be dealt with effectively only by consent.

These are the kind of social changes which organisations need to take heed of if they are to survive. Difficult as it might be, they are social forces which, if understood, can be managed. In the light of and in conjunction with the previously mentioned technico-economic controls, information is also required on the following aspects of the social climate:

(*a*) Trends in labour turnover and absenteeism.
(*b*) Future manpower needs.
(*c*) Changes in job demands relative to existing wage differentials.
(*d*) Increase or decrease in restrictions on overtime, piece-work, speed of work and general opposition, all of which affect the organisation.
(*e*) Measurement of the movement in the value of the human assets as proposed by Likert and mentioned in Chapter 7.

SOCIO-TECHNICAL SYSTEMS

Until recently, there have been two general approaches to improving organisations. From the early beginnings of the industrial system right up to the present time, industrialists and academics were preoccupied, as some still are, with the technical aspects of the organisation. This approach was almost solely concerned with such things as plant, methods, lighting and so on. Then, with the advent of the so-called human relations school during the 1920s, attention was switched to the social aspects. This thinking gained ground during the fifties and sixties. The former and latter schools have been termed by Lupton (1969) as hard-nosed and soft-nosed. Clearly, as some now appreciate, it is neither one nor the other but elements of both that play a part in organisational difficulties. Herzberg (1959) sees the problem of designing jobs to suit people rather than the other way about or what the hard-nosed protagonists support. The Tavistock approach, which really complements the Herzberg philosophy, is outlined by Hill (1971) in the company development programme carried out at Shell U.K. Ltd. In essence, this is attempting to develop the technological and social systems as an integrated whole, a philosophy which is also reconciled to a policy of joint optimisation of resources. This objective recognises that the aim should be 'the best' in the circumstances prevailing, as distinct from the maximum use of resources. The message which we can glean from all this is to be wary of easy answers and to remember that what we do to one part of the organisation could affect another part in a negative way.

CLARIFYING OBJECTIVES

Any attempt at improving an organisation must be preceded by a clarification of what we want to achieve. The Shell philosophy is a policy of joint optimisation of resources; a small company might set itself an objective of increasing its market share by 50 per cent from the current 12 per cent to 18 per cent. Certainly, meaningful objective setting will necessitate the obtaining of information about the current position of the company in both the technical and social areas of activity.

The procedure for selecting the most suitable objectives can perhaps be dealt with by a combination of the following three ways:

1. Intuitive, entrepreneurial or natural flair is still, and always will be, the real driving force of any company, but can still benefit from the next two.
2. Taking a management-by-objectives approach as developed by Humble (1970) and giving particular attention to the following factors about the organisation:
   (*a*) Belief about the next five years.
   (*b*) Opportunities and threats.
   (*c*) Strengths and weaknesses, both technical and social, in the organisation.
   (*d*) What is the distinctive strength?
   (*e*) Where should we go?

These are so-called strategic plans covering the overall deployment of resources. At departmental level, tactical plans would also require determination.

3. Using the approximate value system developed by Churchman and Ackoff (1954), it is possible to assign quantitative weights to qualitative objectives. The procedure consists essentially of three steps:
   (*a*) Listing the objectives which are to be considered.
   (*b*) Tentatively listing objectives in rank order of importance.
   (*c*) By value theory, confirming or modifying the tentative ranking.

   By a similar method, Martin (1964) has shown how to evaluate the contribution made by various functions or organisational objectives. An example illustrating the use of this procedure is contained in Fig. 9.1.

Whichever method is adopted, the mere discipline of systematically thinking through an organisation's objectives is bound to be beneficial.

MANAGERIAL EFFECTIVENESS

An important prerequisite for bringing about change is the attitude and effectiveness of industrial managers. Indeed, if they do not feel positive and optimistic about their own futures, it is likely to be reflected in their job and in the attitudes of their subordinates. There are mixed opinions about what affects managerial efficiency, but research carried out by the present writer made use of the factors listed in Fig. 9.2. An explanation of these factors is also included in Table 9.1 with a space provided for an assessment of each factor by rank order of importance. It can be seen from this list that the manager's job depends on a number of interrelated aspects in this complex thing we call works organisation. It is also a useful way of showing how in this whole series of books each contributes to the important aim of increasing not only managerial effectiveness but organisational performance. If management is really committed to change and does not deal with it in a sincere and professional way we can expect opposition, but of more importance is the fact that no change will occur. Moreover, as Wilkinson (1970) has pointed out, 'success is

Objectives considered important in next 12 months	
Objective	**Value**
1. Increase total earnings productivity by 10%	.60
2. Improve stagnation factor by 20%	.25
3. Improve delivery performance by 20%	.15
Total	1.00

Activities which will affect the achievement of objectives

Sales/Design/Quality	
Activity	**Value**
1. Change product mix	.30
2. Improve quality productivity	.15
3. Introduce work specifications	.08
Total	.53*

Production	
Activity	**Value**
1. Change to a group layout	.20
2. Change wage-payment system	.10
3. Improve operation planning	.08
4. Decrease down-time by 10%	.05
5. Improve maintenance productivity	.04
Total	.47*

Policy statement: Capital expenditure not to exceed £100,000
Members of valuing panel: Managing Director, Sales Manager
Chief Designer, Chief Accountant and Works Manager

* Note: These two values total to 1.00

Fig. 9.1. Valuing objectives

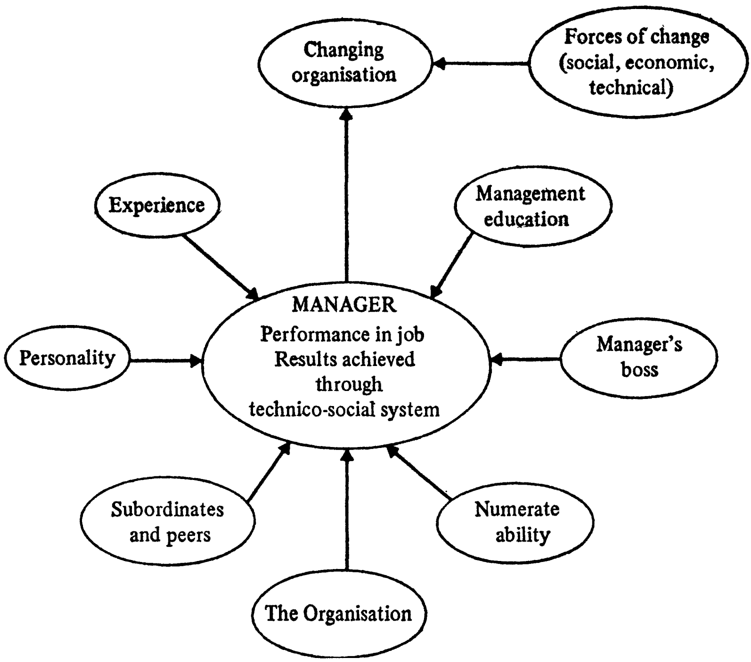

FIG. 9.2. Factors affecting managerial performance

impossible if the management is only prepared to "decorate" the *status quo* and will not risk changing it'.

INTRODUCING CHANGE

The vital point is how to introduce effective change, that is, change that leads to some improvement in the socio-technical system. Perhaps we ought first to start from the premise that we are going to manage the change and not let events take over from us. Next is the need to clear our objectives in the light of where the organisation is now vis-à-vis its external environment. Third is the assumption that both through the formal and informal systems we have all the relevant information or as much as can be economically justified. Fourth is the need to recognise that conflict is a natural and inherent part of any change process. Indeed, it is possibly only when conflict emerges that any real understanding of the issues can be revealed.

Table 9.1

MANAGERIAL PERFORMANCE EVALUATION SHEET

No.	*Factor*	*Rank order*
1.	*Experience.* Includes experience in dealing with people, knowledge of the industry, technical knowledge and general socio-technical experience.	
2.	*Management education.* This is the knowledge imparted on management courses; would include such subjects as costing, economics, work study, law, industrial relations and organisation theory.	
3.	*Personality.* This concerns the ability to apply experience and knowledge. It involves self-awareness, communication effectiveness, and the ability to work through power systems.	
4.	*Manager's boss* is the immediate boss. Consider the extent to which he gives discretion, stretches, challenges and stimulates the achievement of results.	
5.	*Subordinates and peers.* These are the people who occupy subordinate and horizontal roles, and involves their attitude to the manager and the organisation.	
6.	*The organisation.* Includes the nature of the manufacturing system, personnel policy, industrial relations climate, managerial style and external forces.	
7.	*Numerate ability.* The skill of asking for and making effective use of relevant facts and figures. It also includes the ability to make appropriate use of measurements, standards and controls.	

Much of the current industrial relations difficulties are no doubt due to each side having different perceptions of the problem. The fifth requirement is the process of developing understanding and agreement about the facts and information being presented. Let us also remember that even when we have understanding and agreement we may still not have commitment to action. The sixth and last aspect is the change agent – a current piece of jargon which relates to a person, a group of people or a procedure which aims to bring about some change in a system. Although Argyris (1970) considers that change agents often become too involved with the situation and take up biased attitudes without realising it, anyone who wants to bring about change smoothly must avoid assuming fixed positions. Instead, Argyris suggests the idea of the interventionist as someone who helps groups of people to understand and deal with problems in a way that suits them best. This whole process for dealing with change is illustrated in Fig. 9.3.

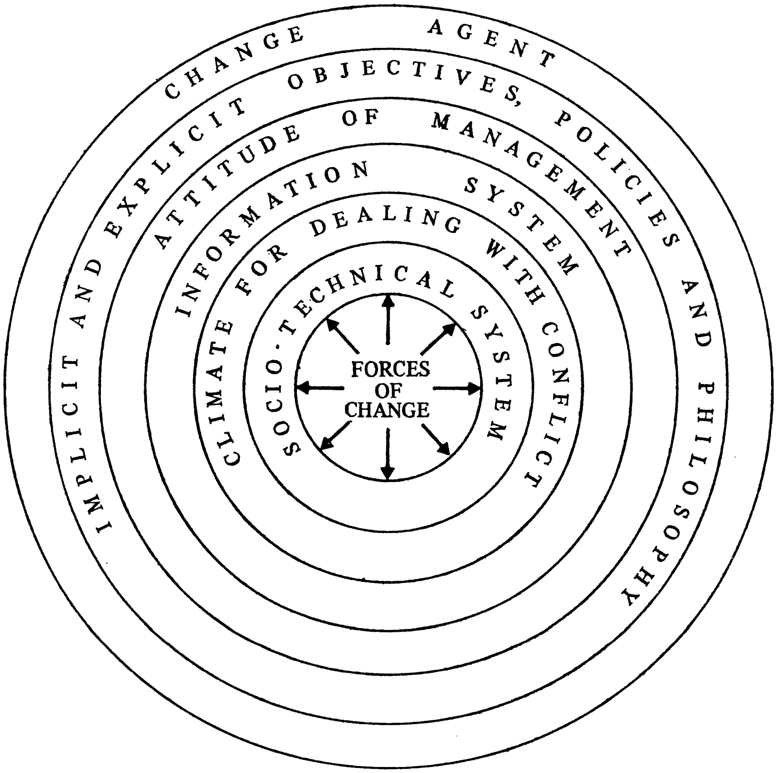

FIG. 9.3. Introducing change

DEVELOPING UNDERSTANDING

Probably one of the biggest obstacles to the effective implementation of change is lack of understanding. This is due to a number of reasons. Some are relatively easy to deal with, the rest require a good deal of time and patience. The more straightforward aspects revolve around the way in which information is presented. It needs to be simple, using language and ideas that can be understood by all concerned. But this is only the first stage in developing a real understanding; the later stages of agreement and commitment are some way off. To foster initial comprehension requires feedback or two-way communication. For example, if a change is proposed in a wage-payment system at a meeting of shop stewards, discussion sheets might be issued which enable everyone to work through each stage in the proposal. All this takes time, and there might still be opposition, but at least both sides will be disagreeing about the same thing.

Another concomitant for effective two-way communication is a willingness to listen and to appreciate that other people perceive issues in different – sometimes totally different – ways. Certainly, the skilled interventionist is sensitive to the situation; he is not

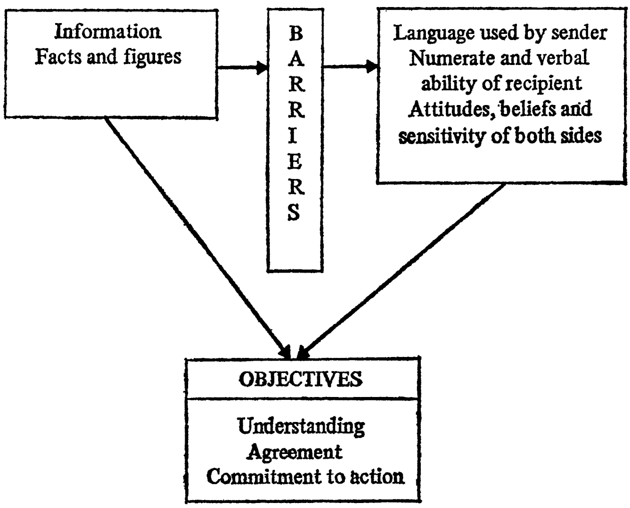

FIG. 9.4. Barriers to understanding

necessarily sympathetic, but rather in a neutral way helps to develop understanding. Some of the difficulty can also be removed by presenting information in a less conflicting form. The mistrust of profit is one case which still creates communication barriers. Possibly the use of the total earnings concept which recognises the aim of maximising remuneration to all concerned might be more acceptable.

Improving organisations, which by implication involves changes, very much requires sincere attention to this difficult area of communication. Really effective communication is going to involve a lot of patience and a large investment in time. If, however, we do not appreciate this, we can expect hostility, suspicion and indifference. A diagram depicting this problem of barriers to understanding is outlined in Fig. 9.4.

ORGANISATION DEVELOPMENT

Many companies have been carrying out a process of organisational development for some time, although they probably have not called it this. Furthermore, some have done it well, those who have ignored it or done it badly are struggling or have failed. Whatever we call it and however we deal with the problem when seen against the searching changes taking place, the problem will not go away. Therefore we shall all need to give more formal attention to developing our organisations to meet the demands of a changing internal and external environment. Unfortunately, there are still only a handful of companies who have consciously set about redesigning their organisations. Certainly, the plea made throughout this book is important: there are no universal answers and each situation will require an analytical approach and a big investment in time and patience. The significant points which have been raised are summarised in the following list:

1. How clear are the objectives, policies and philosophies and have they been determined by consent?
2. How effectively is information received and handled?
3. What is the nature of work group and individual relationships?
4. What are the internal and external threats?
5. Is the existing organisation structure considered suitable?
6. What are the characteristics of the real power system?
7. Is the existing reward system suitable and how stable is it?
8. How high are the achievement aspirations of managers?
9. How appropriate is the value system of managers?
10. How effective were past methods for dealing with change?
11. Should be approached on an open-ended flexible basis.
12. Should be part of some tangible and readily understood change such as a productivity improvement.
13. Organisational change is a long process and should not be rushed.
14. We should appreciate that some people will see change as a personal threat.

15. The aim should be to create a climate for change which is associated with success and leads to effective group problem-solving.
16. There should be a representative system for ventilating and resolving conflict.

CONCLUSIONS

The aim throughout this book has been to sketch out a framework for understanding and improving the works organisation. It has also endeavoured to set the scene for this whole series of books, the subject-matter of which all contributes to this understanding.

The theme has been one of analysis and flexible thinking. It has been shown that a works organisation is a complex entity composed of the manufacturing system and the structure of relationships, or what has been called the technico-social system. While many of the problems facing companies will not respond to easy solutions, this should not divert us from what, in some cases, are simple obvious answers. On the other hand, organisation problems are often open-ended and can therefore only be dealt with on a flexible basis.

Productivity measurement and objective setting have received attention because we shall never know whether things have improved unless we measure what we were trying to achieve. Again, this activity will be unique to each company, but some of the indices of efficiency could be common, particularly the concept of total earnings. Nevertheless, measurable targets and a commitment to action are an essential prerequisite to survival, recognising at best that decision-making only represents a coalition of varied interests and should involve some consent.

The topical subject of change has received a lot of attention – and rightly so, since it is here to stay. But to deal with it so that human values are satisfied and productivity assured will require a mixture of nerve, patience, flair and sensitivity to human hopes and fears.

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