

Guide to production control —

Part 3: Ordering methods

Committees responsible for this British Standard

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- British Computer Society
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- Chartered Institute of Management Accountants
- EEA (the Association of Electronics, Telecommunications and Business Equipment Industries)
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Foreword

This Part of BS 5192 has been prepared under the direction of the Quality, Management and Statistics Standards Committee.

The prime objective of production control is to help a company become more competitive and profitable. An effective production control function endeavours to fulfil this objective by keeping a balance between satisfying sales demand, achieving high plant utilization and maintaining low investment in stocks and work-in-progress. An optimum balance between these often conflicting objectives will only be achieved by a production control system designed to meet the specific needs of the company and run by well trained and dedicated staff.

BS 5192 is published in six Parts and gives comprehensive guidance in those areas that are considered essential for effective production control.

— *Part 1: Introduction: Scope of the guide, purpose of production control, relationship to other functions, technological changes, choosing the system to fit the business;*

— *Part 2: Production programming: Relationship to corporate and business programmes, planning techniques, master production scheduling, capacity planning;*

— *Part 3: Ordering methods: The various types of ordering and stock control systems, comparing the advantages of each for particular applications;*

— *Part 4: Dispatching (shop-floor control): The methods of shop-floor production control and documentation involved and the increasing influence of computers;*

— *Part 5: The relationship between control and other management functions: The production control information flows in the organization, their generation, presentation, use and maintenance;*

— *Part 6: Computer aided production control: The application of computer software to the production control function;*

Throughout this standard use of the pronouns he, him and his is intended to be non-gender-specific.

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Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, pages 1 to 36, an inside back cover and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

Introduction

This Part of BS 5192 describes the second stage of production control (see Figure 1). It covers the methods used to order the manufacture of components to be made in the company's workshops and to instruct the company's buyer concerning the deliveries of purchased parts and materials that are required from suppliers. An effective ordering system should avoid the pitfalls of excessive stock holding at one extreme or stock shortages at the other end of the scale.

1 Scope

This Part of BS 5192 gives guidance on ordering in all types of production industry ranging from the simplest to the most complicated case of engineering multi-product batch production. It describes the decisions to be made and the systems and methods that can ensure that these decisions are made efficiently. A number of ordering systems are described together with their applicability. The level of detail is sufficient to guide the readers on the choice of a system or systems appropriate to their industry.

2 References

2.1 Normative references

This Part of BS 5192 incorporates, by reference, provisions from specific editions of other publications. These normative references are cited at the appropriate points in the text and the publications are listed on the inside back cover. Subsequent amendments to, or revisions of, any of these publications apply to this Part of BS 5192 only when incorporated in it by updating or revision.

2.2 Informative references

This Part of BS 5192 refers to other publications that provide information or guidance. Editions of these publications current at the time of issue of this standard are listed on the inside back cover, but reference should be made to the latest editions.

3 Definitions

For the purposes of this Part of BS 5192, the definitions given in BS 3138:1992, BS 5191:1975 and BS 5192-1:1993 apply.

4 The order

4.1 Purpose of an order

Ordering is the first stage in the process of executing the production programmes described in BS 5192-2. An order is an instruction to make or purchase an item contained in a product.

4.2 Push and pull ordering systems

There are two ways in which order action can be generated: either directly from a production programme or indirectly from a stock control system (to replenish stock as a result of stock being consumed). The former method is described as a push system because it pushes material into the manufacturing process to meet a demand and the latter is known as a pull system because material is pulled through the factory by demand.

4.3 Dependent and independent demand

Ordering systems can be further classified as those that treat demand as dependent and those that treat demand as independent. Manufactured products with some exceptions consist of two or more items. Manufacture depends upon bringing together all the items required to make the product in the right amounts and at the right time, i.e. the demand for each item is dependent. In non-manufacturing situations, for example in a finished goods warehouse, demand for each item is usually independent of the demand for every other item.

4.4 Choosing the right ordering system for the business

Ordering systems are described in clause 5 together with an explanation of their application to particular industries. Different situations require different solutions and it is quite common for businesses to use more than one system or a combination of systems. The latter are sometimes known as hybrid systems. It is essential that the user selects systems that are not over-complex yet are sufficiently resilient and comprehensive to meet all conditions of the particular operation.

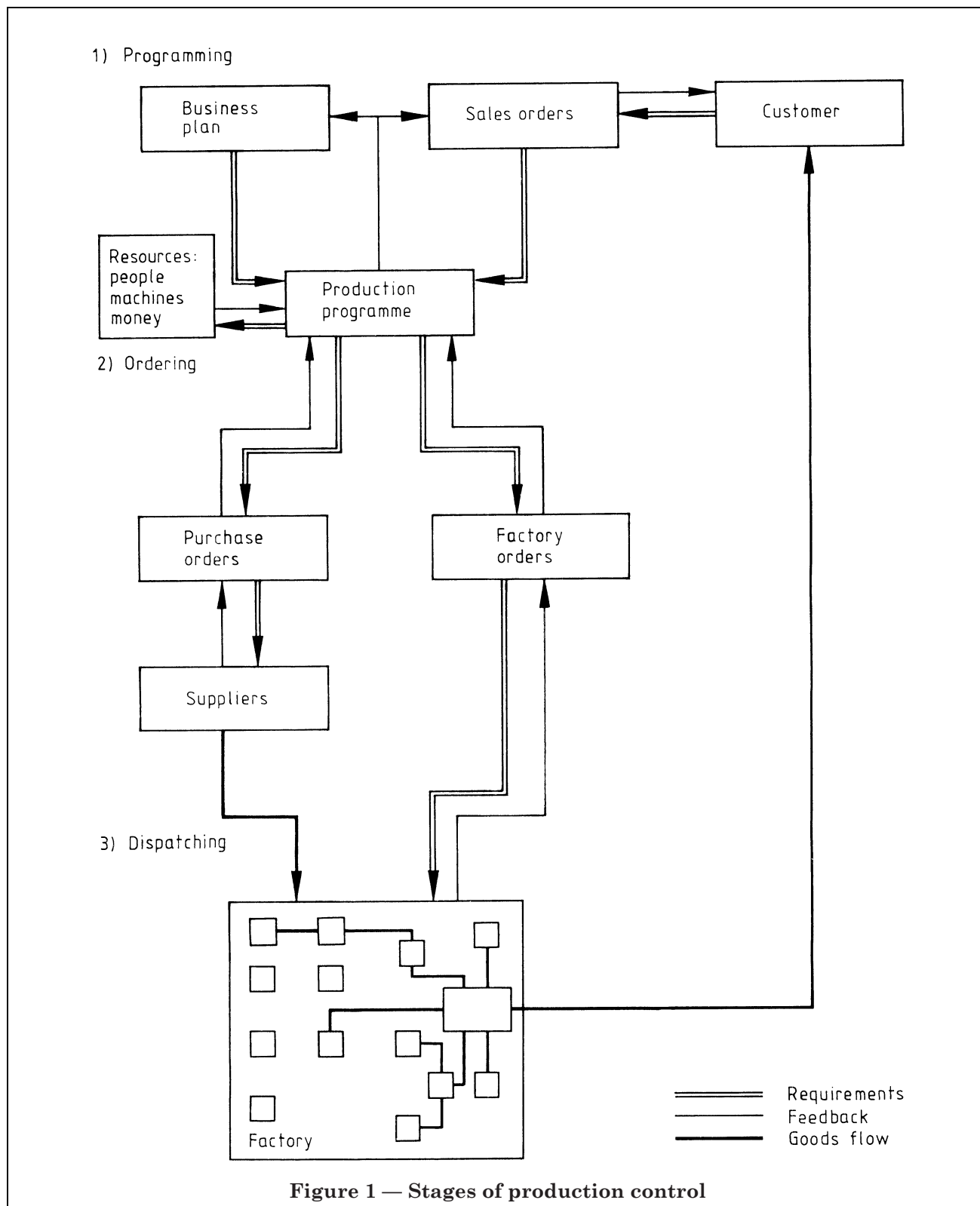
4.5 Ordering decisions

4.5.1 General

Before an order can be placed the following decisions need to be taken:

- a) what to order;
- b) how much to order;
- c) when to order;
- d) when to deliver;
- e) whether to make or buy.

These decisions are considered in 4.5.2 to 4.5.6.



4.5.2 What to order

As explained in BS 5192-2, a production programme is a statement of what finished products are to be made, how many are needed and when they are required. A finished product, or end item as it is sometimes called, is a product that is offered for sale. It can be either a complete product, a service part or a byproduct. To translate the programme into action, an order should be raised for the finished product itself. This in turn will trigger demand for all the items that comprise the finished product. A product may comprise a single item of raw material, e.g. steel used to make a forging, or many thousands of items as in an aeroplane.

It is therefore necessary to know the content of the finished product and the way it is structured. Content defines the items and their amount and it is presented in a parts list, formula or specification. Structure defines the hierarchy in which the items are put together or assembled. A parts list that arranges the items in structured form is known as a bill of material. Figure 2 is an example of a bill of material.

4.5.3 How much to order

The bill of material shows the quantity of each item needed to make the next level up in the bill. For example in Figure 2, three of item X are needed to make item C; two of item C which are needed to make item A. Therefore, six of item X are needed to make item A. The following are types of order quantities.

a) *Discrete order quantity.* The order quantity can be exactly that required to meet the immediate programme, i.e. if the programme calls for 10 of item A per week/day/hour, then the order for item X will be 60 per week/day/hour. This is called a discrete or lot-for-lot order quantity.

Should the item be common to more than one product, the quantity may be increased to aggregate concurrent requirements from several products. If there is surplus stock of the item arising from past orders, the quantity may be reduced by the amount surplus.

b) *Batch quantity.* The order quantity may be further adjusted by aggregating quantities from several time periods to take account of batching rules or policies set by production management.

The purpose of batching is to reduce the cost of administration and of setting up machines or, in the case of purchased items, to gain the benefit of purchase quantity discounts. However, the larger the batch size relative to immediate requirements, the greater the cost of holding stock. The most economic quantity is in theory the one for which the cost saving in the production process balances or equals the cost of holding stock. A mathematical relationship known as the economic order quantity formula can be used to calculate economic batch quantity. The formula is difficult to apply in practice because of the difficulty of determining accurate values for the cost factors used in the formula. Many businesses use instead simple rule-of-thumb methods for calculating batch size. Examples of such rules are “the batch quantity is not to exceed one month’s estimated usage” and “the operation time for a batch is not to exceed one week”.

Similar rules apply for deciding whether or not to accept a quantity discount from a supplier. In purchasing, a situation can arise where it is expedient to order more than the immediate programme requires in order to take advantage of pending price increases or to avoid shortages arising from breakdowns in the source of supply. Such decisions should be made with great care as they can cause gross overstocking.

Further explanations of the way batch size may be calculated are given in clauses 6 to 9 which cover individual ordering systems.

Conventional cost accounting systems favour large batch sizes since set-up costs and purchase discounts are readily identifiable whereas stock holding costs are not easily quantified. However, large stock holdings impose severe penalties on the business in terms of high interest charges on capital tied up in stock, loss of flexibility, slow response to customer demand, increased risk from stock obsolescence and unproductive use of floor space.

These penalties are now widely recognized with the result that there is a move towards reducing batch sizes. This move has been helped by advances in production engineering which have made possible very significant reductions in plant set-up times.

4.5.4 When to order

The latest date by which an order for an item has to be issued to meet a programme demand is obtained by back scheduling from the completion date in the programme through the lead times of higher level items in the bill of material as well as the lead time of the item itself (see Figure 3). See clause 6 for when to order in a stock control system.

Lead time is often difficult to estimate since it can vary from order to order depending on a number of circumstances: supply source, factory load, batch size, season, etc. Experience will help to determine a reasonable lead time under normal conditions.

In many factories parts spend on average 93 % of their manufacturing lead time queuing between operations, there is considerable scope for lead time reduction. In practice this often takes the form of expediting to achieve earlier delivery, but this can also delay other items. The emphasis should be on reduction of lead times by reducing queueing time for all items.

An order may be issued earlier than the latest date though this may cause delivery to be made earlier than required, especially with purchase orders, unless there are control procedures to prevent this happening.

4.5.5 When to deliver

Delivery date is the latest order date for the item plus the lead time of the order (see Figure 3).

4.5.6 Whether to make or buy

Make-or-buy decisions can broadly be divided into long term and short term. Long term decisions are generally dictated by manufacturing policy and the need to concentrate on what the business does best and most cost effectively. For example, a business may decide to concentrate on assembly and buy all materials and components, or a decision may be made not to replace capital equipment at the end of its useful life and to buy the items formerly produced on the equipment. However, even though purchasing may be more economical, a business may decide in some circumstances to retain or acquire a manufacturing facility for strategic reasons, for instance, to retain flexibility, to avoid dependence on outside sources or to give the customer a rapid service.

In the short term, a decision to buy is usually made in order to relieve a temporary overload and this kind of buying is known as subcontracting. Some businesses, as a matter of policy, deliberately limit internal capacity and subcontract the overload in peak periods in order to avoid having idle capacity.

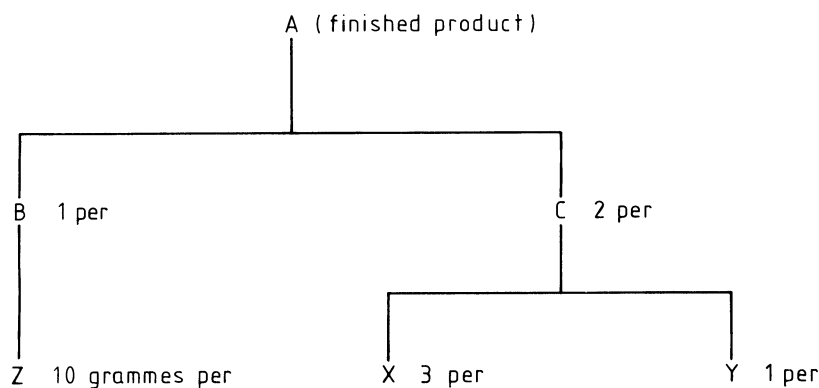
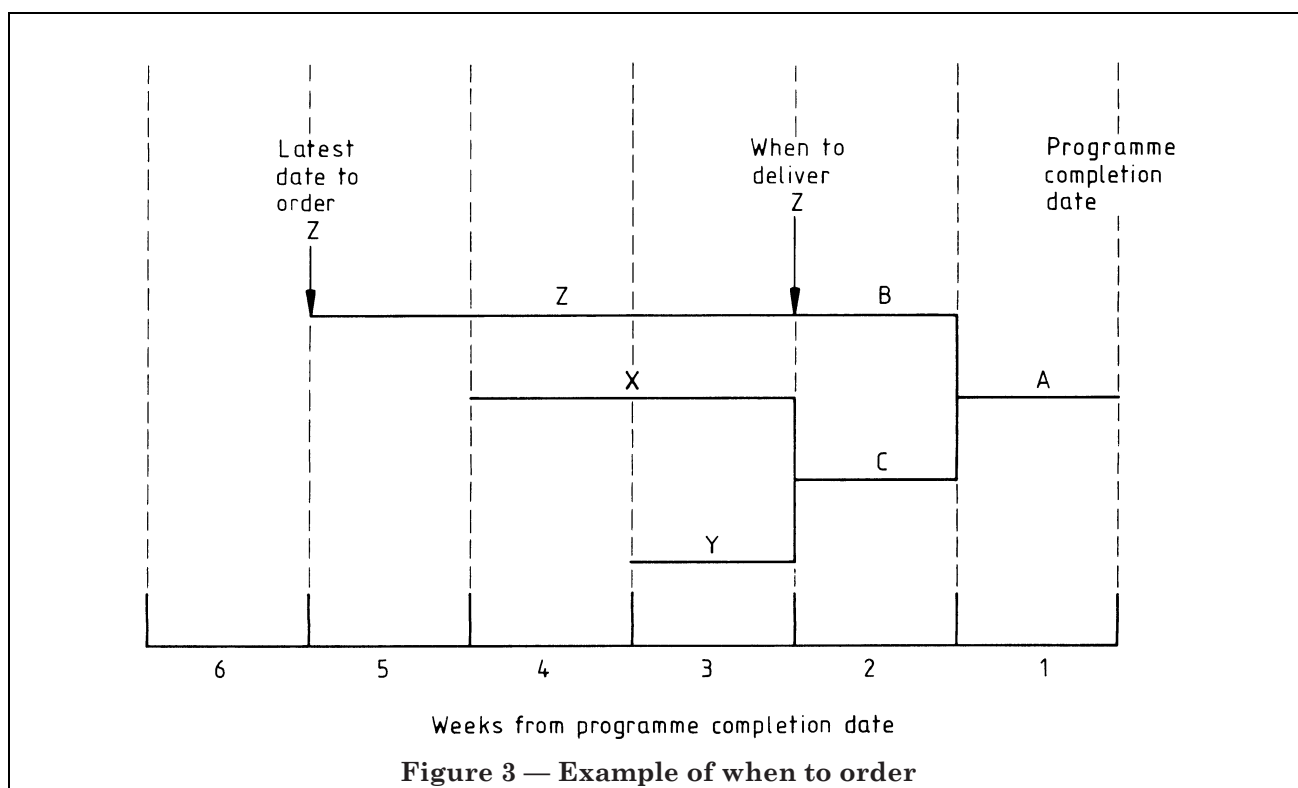


Figure 2 — Bill of material



4.6 Content of an order

4.6.1 Factory orders

The minimum information needed to execute an order in the factory is as follows:

- a description of the item to be made or supplied;
- a description of the material and parts it is to be made from and the amount;
- the quantity to be made;
- the date/time by which it is to be made;
- the order identification.

Descriptions should be unambiguous and sufficiently comprehensive for the recipient to understand. Part numbers or codes should have a unique identity so that the item cannot be confused with any other. It is advisable in all documentation and computer displays to show both part number or code and description together as one can serve as a check against the other.

An order identification is essential. It is required for the purpose of tracking and progressing the order and in some cases for costing it.

The information may not necessarily appear in one document. For example, completion date may change between the time the order is raised and the time it is executed. This could be due to changing circumstances, such as an alteration in customer and shop floor priorities. To have to change completion dates on a mass of paperwork can be inconvenient and time consuming, but incorrect completion dates are misleading. It is therefore desirable to hold completion date information on a separate document. Such a document is sometimes known as a work-to list. It is issued to the shop-floor daily or weekly and tells shop supervision what jobs are to be executed that day or that week. The final assembly schedule described in BS 5192-2 is a particular form of the work-to list.

It is also advisable to have separate documentation for information about the material from which the item is to be made. This documentation is called a material requisition or, in the case of assembly operations, an assembly requisition, kit list or parts list. It gives the shop-floor authority to draw material from store. The documentation is separated from the rest of the order documentation and is used subsequently to update stock and costing records.

Items a) to e) are the essential information needed to handle a factory order; it should be remembered that this is the minimum needed. In practice much more information can be, and often is, added. The following information may also accompany an order:

- 1) routings (the sequence of operations which the item needs to follow);
- 2) production methods and times;
- 3) shop numbers, machine numbers, labour grades;
- 4) tool numbers;
- 5) engineering or technical specification;
- 6) job number, cost code, project number, sales order number.

It is customary to hold the permanent elements of the information such as production methods and engineering specifications in files on the shop-floor. This reduces the amount of paperwork that has to be reissued with each order.

4.6.2 Purchase orders

Creation of a purchase order normally involves two documents:

- a) the purchase requisition;
- b) the purchase order.

A purchase requisition is an internal document that is issued by the production or stock control function to the purchasing function. The requisition contains a description of the item to be purchased, the quantity and the required delivery date.

The purchase order is the contract between the buyer and supplier. In addition to the information given in the basic purchase requisition, it contains details of price and terms, location for delivery, technical specification or supplier's catalogue description, etc.

A purchase order may state a bulk quantity and ask for delivery to be phased over a period of time, e.g. so many per week. Alternatively, the purchase order may refer to a separate document, the call-off schedule, for delivery details. Call-off schedules are used extensively in high volume industries such as consumer goods. The purchase order states the estimated total quantity required over (say) a year so that the supplier can plan his production and reserve resources.

There are many variations of the call-off schedule, but a typical schedule would show required deliveries per week for the following four weeks, then per month over the following three months. Schedules are issued on a rolling basis with a period of overlap. The purchase order should state the buyer's liability in the event of total or partial cancellation. For instance in the above example, the buyer might accept full liability for the first two months of the schedule and liability for material only for the following two months. A substantial deficit in deliveries requested over the whole year compared to the total in the purchase order might call for a price revision.

4.7 Information feedback

An essential part of any ordering system is the means to feed back information about the state of the order in comparison to plan. An order that is issued, known also as an open order, should be closed when it is either fully or partially completed. An order that is not proceeded with should be cancelled and promptly removed from the system.

To facilitate the feedback of information, order documentation can be printed with bar coded or magnetic strip data, the former method being the most common. Data recorders situated in the factory read the information from the order documents directly into a computer system on completion of the order or a stage. This reduces the amount of data that has to be keyed in on completion, since, usually, the only variables that have to be entered are the quantities produced and rejected.

Methods for controlling and tracking orders are described in BS 5192-4.

4.8 Paperless systems

Paperless order systems are beginning to make an appearance though the completely paperless factory is still some way into the future. The following are two examples of paperless ordering so that applications that currently exist.

a) *Computer integrated manufacturing (CIM).*

The planning department transmits order instructions via a computer system to a manufacturing cell in which the machines and the transfer equipment are controlled by computer.

b) *Electronic data interchange (EDI), linked to the supplier.* The buying department transmits orders via computer over the public telephone network into the supplier's computer system. Acknowledgements and invoices can be similarly transmitted.

5 Ordering systems

5.1 General

In most companies there are hundreds, or even thousands of different orders to be planned, issued and controlled. It would be impossible and also highly undesirable to treat each order as a separate independent problem.

Ordering systems are needed, first, to control the very large number of decisions to be made and, secondly, because the very detailed analysis necessary for treating each component separately as an entirely independent item can only lead to inefficiency.

5.2 Systems

The systems required are feedback control systems of the general type illustrated in Figure 4. The parameters are set for a given production requirement; examples of parameters are the order quantities, run quantities and transfer quantities which have already been examined.

The output variables represent the aims of the system. These are variables that the manager can only alter indirectly by changing the values of the parameters. Examples are product output, cost, profit, stock levels.

The input variables are those over which the manager has little or no control, but which have some effect on the outputs from the system. In different factories these may include such variables as the weather, the bank rate, the dollar exchange rate and the competition.

The characteristics of the system itself may also be changed by means of the system parameter settings. Changes to the system design will vary the way in which production relation parameters affect the output variable values.

The system is regulated by planning future values for the output variables and by issuing these plans in the form of executive orders to the factory. Production output is regulated, for example, by the issue of programmes and orders.

Control is the process of management by which achievement is constrained to follow plans. System output is controlled by monitoring, comparing the output with the plans, and feeding back of information about significant variances, so that parameter values can be changed to bring achievement back into line with the plans.

An important aspect of feedback control systems is that in some circumstances they can be unstable and go out of control. Much of the theory of feedback control systems stems from work done in the engineering field on such apparently diverse subjects as speed governors, position control servo mechanisms or electronic feedback amplifiers. Here the instability leads to a phenomenon frequently called hunting. This means that the output quantity does not settle at the required value but continually oscillates between values above and below what is required.

For further details see J.W. Forrester, *Industrial Dynamics* [1].

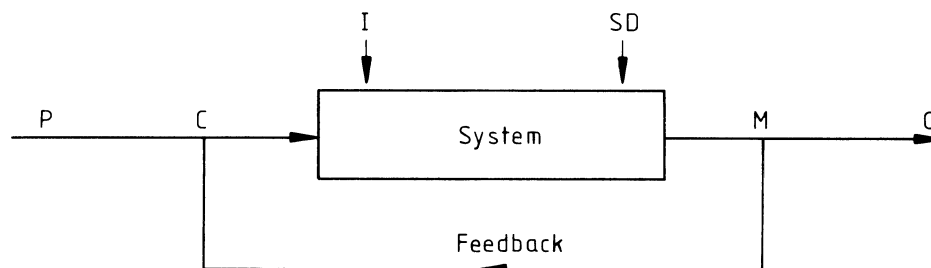
5.3 Objectives in system design

In designing the ordering system there are a number of major objectives including the following:

- a) *Survival*. Survival is normally the first objective in system design. To survive, the company should, among other things, make a profit or maintain its capital in some other way. Survival depends on management efficiency as well as on system design.
- b) *Sensitivity*. Sensitivity is a measure of the speed of system response to changes in output variable value, induced by changes in parameter value.
- c) *Controllability*. Controllability is a measure of the effectiveness with which a system can be controlled. Do appropriate changes in parameter values have a positive and predictable effect on the output variables and how quickly do they act? Controllability is partly a function of sensitivity.
- d) *Flexibility*. Flexibility is a measure of the ability of the system to respond to change. How quickly and efficiently can it respond for example to changes in product design and changes in market demand for the product?
- e) *Productivity*. Productivity is the ratio of system output to the input of resources. The word is normally reserved for the productivity of people, or of machines.
- f) *Profitability*. Profitability can be described as the productivity of capital. It is a measure of the money return obtained with a given investment.

NOTE 1 It used to be thought that it was impossible to achieve all these objectives together and that it was necessary in each case to choose between them. Recent research has indicated that they are much more compatible than used to be thought and that they all require similar basic system design features.

NOTE 2 Ordering systems are only subsystems of production control systems and production control systems are only subsystems of production systems. The best results in system design require a hierarchical, holistic approach, that starts with the design of a good total system.

**Key**

P, parameter;

SD, system design parameters;

O, output variable;

M, monitoring;

I, uncontrollable input;

C, controller.

Figure 4 — A feedback system**5.4 Types of ordering system**

Several types of ordering system are discussed in clauses 6 to 9. These systems operate in different ways according to how they handle the various criteria for making a decision to place an order. The main criteria are as follows.

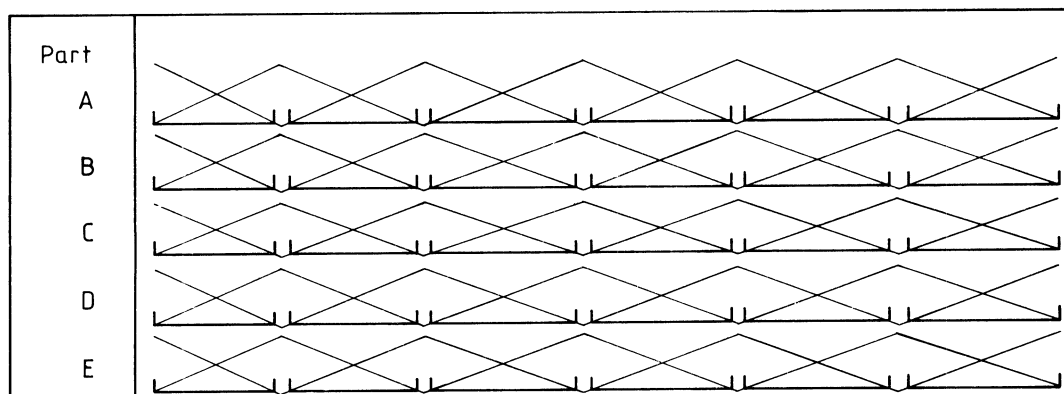
- a) *Bill of material link.* Systems either use this link to trigger new orders (dependent demand) or they do not (independent demand).
- b) *Order status.* Orders may be triggered by firm sales orders that pull the necessary lower-level orders throughout the factory and also by forecast sales orders that cause the lower-level orders to be pushed through the factory to meet the expected sale.
- c) *Order release schedule.* Orders may be released in batches to the factory at regular, fixed intervals through the year (a single-cycle system) and they may also be released as dictated by some other criterion at any time (a multi-cycle system). (See Figure 5.)
- d) *Scheduling.* Orders may be triggered by calculating the release date back from the sales order due-date and also forward from the sales order receipt date.
- e) *Capacity.* Orders may be scheduled by taking into account the available capacity on the next operation's finite capacity and also by ignoring it and using infinite capacity scheduling.

Table 1 indicates how the standard ordering systems handle the criteria listed in items a) to e).

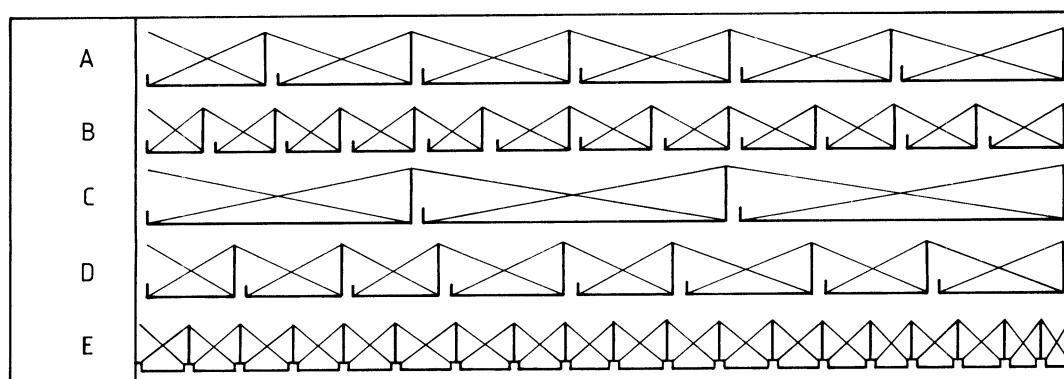
5.5 Related control systems

Ordering systems depend for their efficiency on three main subsystems, known as the controls.

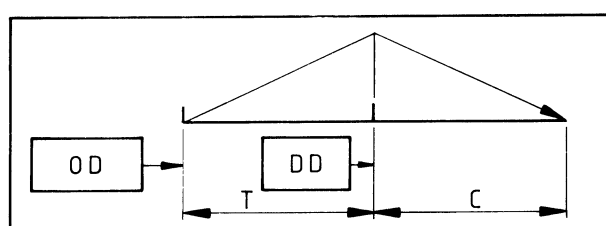
- a) *Progressing.* This is a feedback control system that attempts to constrain the production output to follow the plans in the production programmes, shop orders and purchase requisitions.
- b) *Inventory control.* This is a feedback control system in which actual stock locations and levels are measured and compared with planned stock, so that the investment in stocks and work in progress can be controlled. The design of the production system and the way it is managed have a major effect on the investment in stocks and work in progress.
- c) *Loading.* This is a feedback control system that compares load with capacity and feeds back information to the manager about overload and underload. Loading is important to production control because it makes it possible to determine whether there is sufficient capacity to complete the orders that it issues. Also, it provides the information needed for capacity planning. The short term methods for changing capacity levels in particular, such as overtime, shift working and subcontracting, can only be planned efficiently if accurate data are available about the capacity and load. Longer term projections of the load are used to make the decision on whether to change capacity levels (manpower and/or machine).



1 Single-phase, single-cycle



2 Multi-phase, multi-cycle

**Key**

OD = Order date

DD = Due-date

T = Cycle time

C = Consumption time

Figure 5 — Single-and multi-cycle ordering