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Guide to production control

Part 4. Dispatching (shop-floor control)

STANDARDS

Committees responsible for this British Standard

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British Computer Society
British Production and Inventory Control Society
Chartered Institute of Management Accountants
EEA (the Association of Electronics, Telecommunications and Business Equipment Industries)
Institute of Logistics and Distribution Management
Ministry of Defence
Nottingham University
PERA International (Production Engineering Research Association)
University of Bradford
University of Manchester Institute of Science and Technology

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Contents

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 efficient production control. The Parts are as follows:

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 production 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 pronounds he, him and his is intended to be non-gender-specific.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

Guide

Introduction

This Part of BS 5192 is intended to address the area of production control dealing with the control of actual workflow, movement of work through various workstations and operations in the manufacturing process.

1 Scope

This Part of BS 5192 gives guidance on the procedures and documentation used in production control and makes reference to the use of computers for this task.

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 : Part 1 : 1993 apply.

4 Dispatching

4.1 Definition

Dispatching is the detailed allocation and subsequent control of production resources to individual work orders, necessary to complete orders in accordance with the production programme (see figure 1).

4.2 Dispatching methods

Dispatching can be a simple or complex task depending on the layout and organization of the manufacturing process and on the information feedback requirements of the production control system in use.

In flowline production the operators normally carry out fixed, routine tasks to a constant specification and dispatching is simple.

In batch and jobbing production the number of variables increases substantially and with it the complexity of the dispatching system.

Manual dispatching methods can be highly successful, particularly in simple manufacturing environments. In complex environments, with large volumes of information, it is likely to be of benefit to use the dispatching facilities of a computerized production control system. Documentation can be quickly, accurately and automatically provided and information readily passed between users of the system.

4.3 The dispatcher

In small departments, the dispatching function is normally carried out by the foreman as part of his normal duties. In larger or more complex departments, especially those with a large variety of operations, a specialist dispatcher is necessary to carry out this function. The choice of dispatcher is also affected by the type of production control system in use, manual or computer and the volume and complexity of the information required for control of resources and feedback to the other parts of the system.

A computerized system can often eliminate the need for a specialist dispatcher by reducing the manual workload necessary for documentation.

4.4 Control levels and time spans

The allocation and control of resources can be undertaken for time scales ranging from milliseconds to months ahead and to different depths of detail dependent on the purpose of the allocation and the level of control. Many levels of control may be present in a production control system dependent on the variety and complexity of the work centres and the degree of automation. A typical plant may employ four levels as follows.

a) *Level four* is the strategic level where the manufacture of products or groups of products is allocated to a manufacturing plant or to units within a plant. Time scales will typically be from a week to in excess of a year ahead. For the allocation of production resources it is probable that only the resources that are scarce or whose cost has a major impact on final product costs will be taken into account and the finished products may be grouped. The end result is the master production schedule.

b) *Level three* is the level where the machines to be used in the unit to enable the operations to be performed on each batch of work are determined, where a choice is possible. The sequence in which the jobs will be released is also determined. Level three is the sequence control (or operational control) level and is the level where the process of dispatch is normally

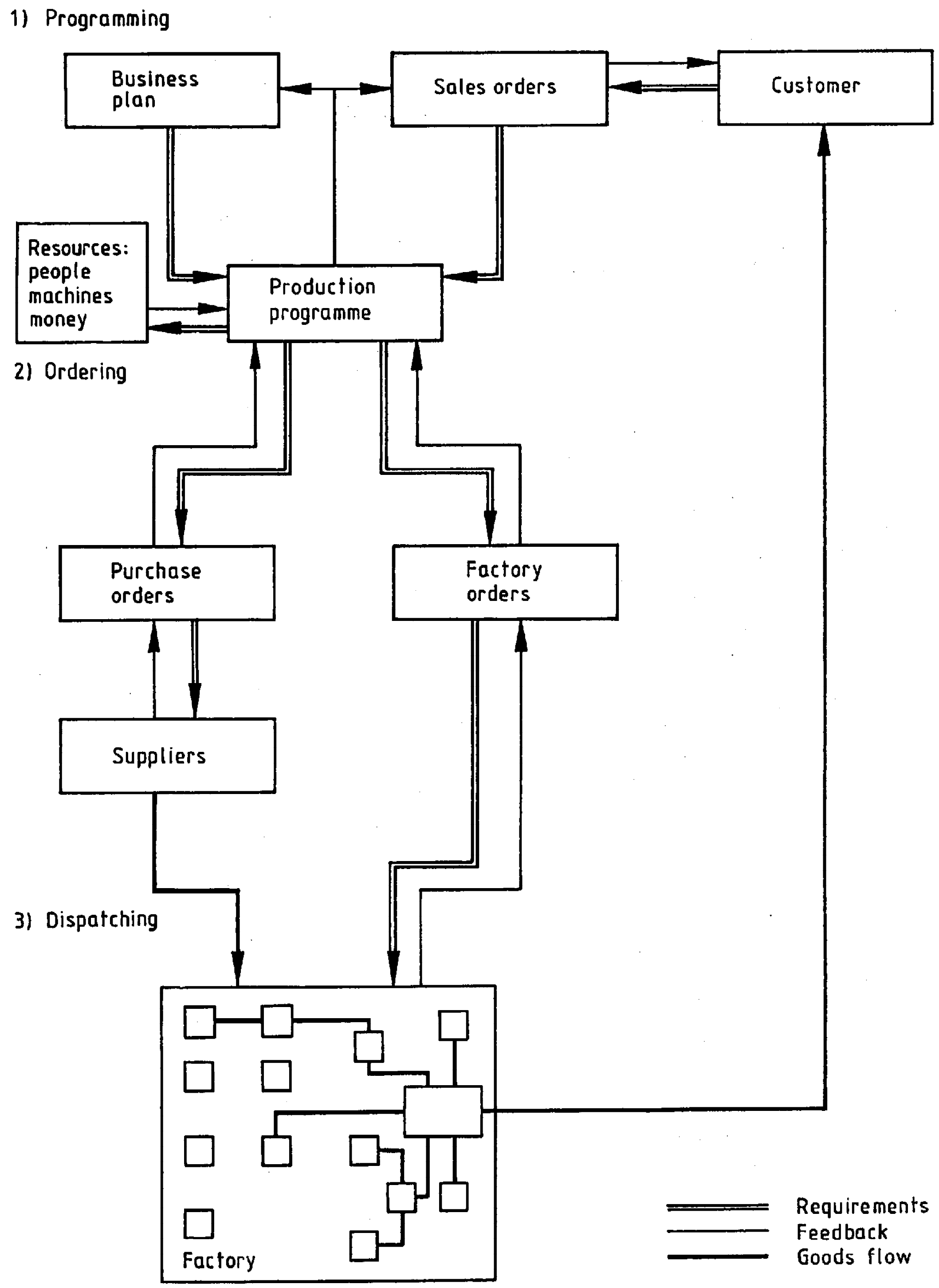


Figure 1. Stages of production control

undertaken. The time span covered is typically from a shift to a week, the output being a work-to-list for each separately identifiable work centre.

NOTE. In a machine shop with numerically controlled machines (possibly segregated into groups of similar machines) there may be the need for two further levels of control; level two, the cell control level and level one, the machine control level.

c) *Level two* contains dedicated processors, each controlling a number of machines within a cell. The cell controller receives the detailed programme from the sequence controller; loads the machine control software into the machine as it is required and receives back details of performance. It covers a time span of, for example, an hour to a shift and is the interface between the dispatching system at the workshop level and the machine controller.

d) *Level one* relates to the actual programmable controller attached to the machine, that controls the individual machine movements and initiates the necessary action when a sensor identifies that there is a malfunction.

5 Shop order documentation

5.1 Documentation used in manufacturing industry

This clause describes documentation typical to many batch and jobbing applications in manufacturing industry. More complex documentation than that described will only be practicable as part of a computerized system. In this case the information, in similar format, can be printed by the system or displayed on appropriately positioned visual display units (VDU). It is not uncommon for the majority of this information to be provided without the use of hard-copy documents. Similarly, feedback to the computerized system can be achieved by direct input from appropriately positioned terminals.

The process of dispatching is normally initiated by the issuing of a shop order set of documents (see figure 2) that typically consists of the following.

a) *Route cards (travellers)*. A route card is a summary of all the operations that will be performed on a batch of work from the initial issuing of materials to the eventual inspection and receipt of finished goods, including details of the machines/work stations where the operations are to be carried out and tooling required for these machines. This information is obtained from the process planning sheet. The route card generally stays with the batch of work, being passed from stage to stage and annotated by supervisors/inspectors when appropriate. It is thus a record of the progress of a job and its current position.

The recording of inspection details may include first-off inspection for an operation (when the first component is inspected after the machine has been set up) and final inspection when the operation is complete. Where work fails inspection a decision should be taken and recorded as to the action to be taken. This will typically be authorizing the material as scrap; downgrading the material and transferring to another order; or authorizing rectification work to bring the material back up to standard. Where such rectification work is significant, it may result in the raising of a new works order.

In addition to the route card it may be helpful to raise a batch identification card that will remain with the batch throughout manufacture and into storage. This can assist stores to operate a first in, first out issue system.

Completed route cards can become part of the goods inward procedure, i.e. they can assist the booking in of goods into stores and stock records. They are then passed to the accounts section for batch costing and finally filed as archive records.

b) *Material requisition (stores requisition)*. The stores requisition is the list of materials required for manufacture. It is obtained from the bill of materials. A materials requisition is surrendered to stores in exchange for materials (and subsequently posted to stock records). For any parts or materials not available a shortage requisition should be raised.

c) *Operation cards (job cards)*. For each operation on the route card one operation card is created, containing quantitative details of the operation. These details are obtained from the process planning sheet. A simple operation card may list the following information:

1) works order reference;
2) batch quantity;
3) production method;
4) equipment to be used;
5) production aids required (jigs, fixtures, etc.);
6) standard time for the batch.

This card can be used as an instruction sheet for the operator(s) and should be fed back after completion of the operation, annotated with relevant information (quantity, time taken, etc.) as part of the monitoring process.

The computerized production control system can be additionally used to set operation control parameters automatically by linking it to microprocessor controlled operations or processes. In this case, the main function of the job card is achieved in a totally different way. Similarly, monitoring information can also be fed directly back from the operation or process to the computerized production control system. Such automated systems need to be integrated into the manufacturing system at the design stage. When in use, an effective system of checks is required to ensure errors are not automatically transferred.

d) *Move cards.* In addition there may be move cards used to authorize the movement of materials or tools to or from appropriate locations.

5.2 Reduction of dispatching paperwork

The complexity of the documentation required for dispatching is dependent on the nature of the manufacturing process. In certain organizations it is possible to adopt a group layout in which groups of machines are established to perform all the processing on a number of similar components. This approach can be extended into what is termed group technology which attempts to gain the advantages of flow production in what would normally be a batch production environment by categorizing output into families of components and establishing flow lines for each family. If period or standard batch control is used with group layouts, dispatching paperwork can be reduced; simple list orders being used to control the flow of materials (see period batch control in BS 5192 : Part 3).

If kanban control is used there is no route card. The stores requisition function is fulfilled by the inter-process kanban. (See **9.7** of BS 5192 : Part 3 : 1993).

6 Provision of resources

6.1 Material supply

The availability of material should be checked and arrangements made to transfer the material from the stores to the first location. If an operation requires a number of materials, e.g. assembly, it is common to marshal all materials into a separate area before the operation commences. Where material is not available a shortage is said to have occurred and prompt action is required to clear any shortages before they interfere with the production programme. This involves either the substitution of some alternative material or the progressing of replenishment orders.

For low value, commonly used materials it may be economic to have a free-issue system where the items are stored close to their point of use and operators allowed to help themselves as appropriate. These stores are replenished at regular intervals from a central store where stock control takes place and such items are normally referred to as bulk issue or consumable items.

6.2 Tooling supply, planning and control

In many industries the tooling, jigs and fixtures necessary to carry out a job are essential and often unique to a particular job. They may also wear with time or be subject to modification in the same way as the parts in a product. Non-availability of tooling or unserviceable tooling is likely to mean lost time on set up or poor quality and scrap during manufacture. In these conditions a company should develop a procedure or system for planning and controlling the manufacture, issue, return, repair and storage of the items.

It may be possible to plan and control the tooling using procedures identical to the material planning and control system. The issue, return and storage of the tools requires an inventory control system. However the provisioning, either manufacture in-house or bought-out and the assessment of tool condition and repair or replacement require special techniques.

Attention should be paid to the following features:

a) planning and control of tooling manufacture that delivers tested tooling on the due-date for first article manufacture;

b) provision of material for in-house manufacture of tools;

c) issue of all tools, jigs and fixtures as part of the kit of parts for the job;

d) tool condition monitoring techniques that drive the planning and control of repair and replacement;

e) costing systems that apportion the capital cost and the operating cost of the tooling in a clear and meaningful manner;

f) an interface to job planning where the number of tools is a constraint and also where a tool may be used for more than one job.

It is essential that all tools and production aids, as specified on the operation card, are made available as and when required. Where a tool is used only in one particular location and is unlikely to require frequent maintenance, it may be stored at its point of use. General purpose tools and production aids are normally placed in a store, separate from the main material stores and with specialist personnel available for maintenance. When group technology is in use, it is often more convenient to store the tools within the group. It is essential that all tool stores are properly maintained with all tools numbered, registered and issued only for a valid and authorized purpose.

Where tools are installed by specialist setters, they will normally be collected by the setter from the tool store as required. If the machine operators do their own setting, the dispatcher is often made responsible for ensuring the delivery of tools to machines as and when required, either by use of operation card or exchange disc (see figure 2).

6.3 Labour and machines

The other major resources required in the production process are, of course, labour and machines. It is important that labour is available in the right numbers with the correct skills and suitably motivated. There should also be adequate capacity of machines with suitable capability. The task of ensuring a suitable labour and machine supply is not normally part of the remit of those responsible for production control.

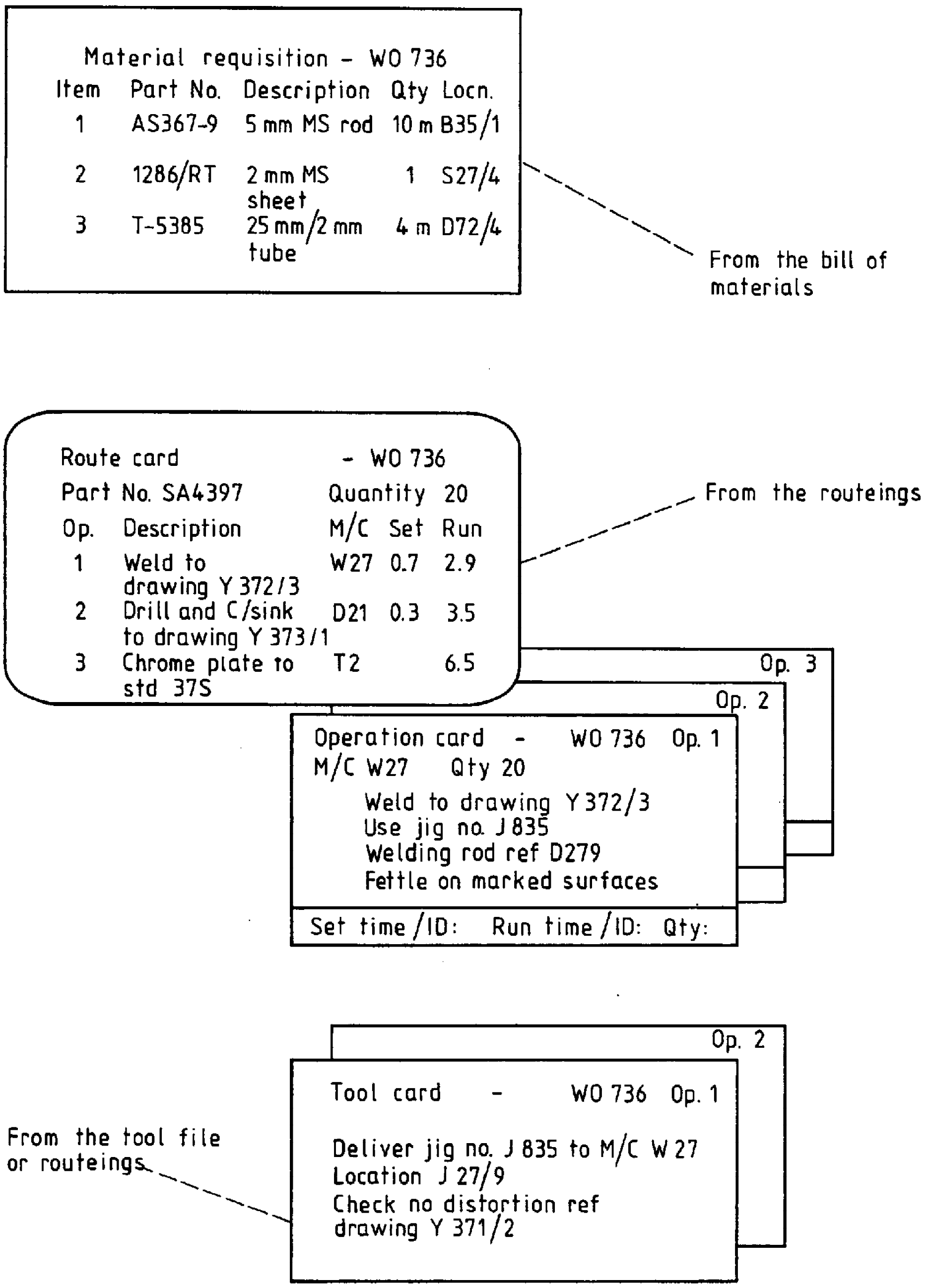


Figure 2. Shop-floor documentation

6.4 Provision of resources using a computer

Computerized production control systems can achieve detailed material requirements planning (materials, tooling and labour) and enable the provision of resources to be better planned and controlled. This is achieved by integrating the dispatching system with other sections of the organization that affect the manufacturing operation, e.g. sales, production control, stores, purchasing, accounts. Manual systems cannot economically achieve this integration.

Whilst an ordering system such as material requirements planning (MRP) can identify where procurement should take place and either manually or by computer assistance take the necessary action to raise/amend purchase orders or works orders, it is still necessary to check that all of the resources are available before the work-to list is generated. If this step is not taken, the work-to list will lose credibility and jobs will be undertaken out of the sequence required to satisfy customers orders or assembly requirements elsewhere on the plant.

Hence it is necessary to check the availability of each resource against the requirement plan. The dispatching system accesses the stock recording system (that could be part of an engineering control system) and checks where resources are available so that jobs are scheduled only if their operations can be executed.

7 Dispatching systems

7.1 General

There are many different systems in use but they can be categorized into three main groups as follows:

a) due-date sequence filing;

b) operation scheduling;

c) priority rules.

In assembly processes the principal function of production control is to ensure that components are available for assembly in time to meet the requirements of the assembly programme. Thus greater attention should be paid to material issue and shortage control systems.

7.2 Due-date sequence filing (see figure 3)

Orders are held in files in different sequences: machine number (or work centre), due-date and part number. The first of these will represent the queue at each machine and the essential task of the dispatcher is to sort the orders into the appropriate loading sequences for the machines. This will usually be due-date sequence but may need to be varied to gain some advantage, e.g. savings in setting-up times. Such a system is easily operated using simple box files (and is sometimes known as the shoe box method).

At the end of each planning cycle, normally 1 day, a new daily plan is made by simply listing the next few jobs for each machine. Copies of this plan are circulated to foremen, machine setters, storekeepers, etc.

As operators complete jobs they should hand in their completed job cards to the dispatcher in return for a card for their next job. The dispatcher updates his records as part of the progress monitoring process.

7.3 Dispatching with operation scheduling (see figure 4)

On receipt of the order the dispatcher loads the different operations against machines or work centres. This is done on a shop-load chart, this may be a proprietary loading system or a handwritten Gantt chart, and provides a visual indication of the forward load and of progress achieved.

7.4 Priority rules

The loading of operations to machines or work centres may be done according to a priority rule. A number of such rules exist as an attempt to formalize the decision making of an experienced dispatcher. An example of a simple priority rule is to schedule first those jobs with minimum job slack, i.e. the amount of free time, over and above scheduled processing time, available before the scheduled completion date.

7.5 Line of balance

This is a manual, graphical technique for planning, scheduling and monitoring progress against key milestones. It is suitable for products assembled over a moderate time period against a firm schedule, development programmes for complex assemblies or research projects.

The technique for determining the line of balance has four stages as follows (see figure 5).

a) Develop a cumulative delivery schedule; the objective chart.

b) Create a network chart for the project; the production plan.

NOTE 1. The production plan control points are as follows.

1) Non-critical stages should be excluded.

2) Closely linked operations or parts should be treated in groups.

c) At appropriate intervals during the project, plot the number of parts completed at each production plan control point on a progress chart.

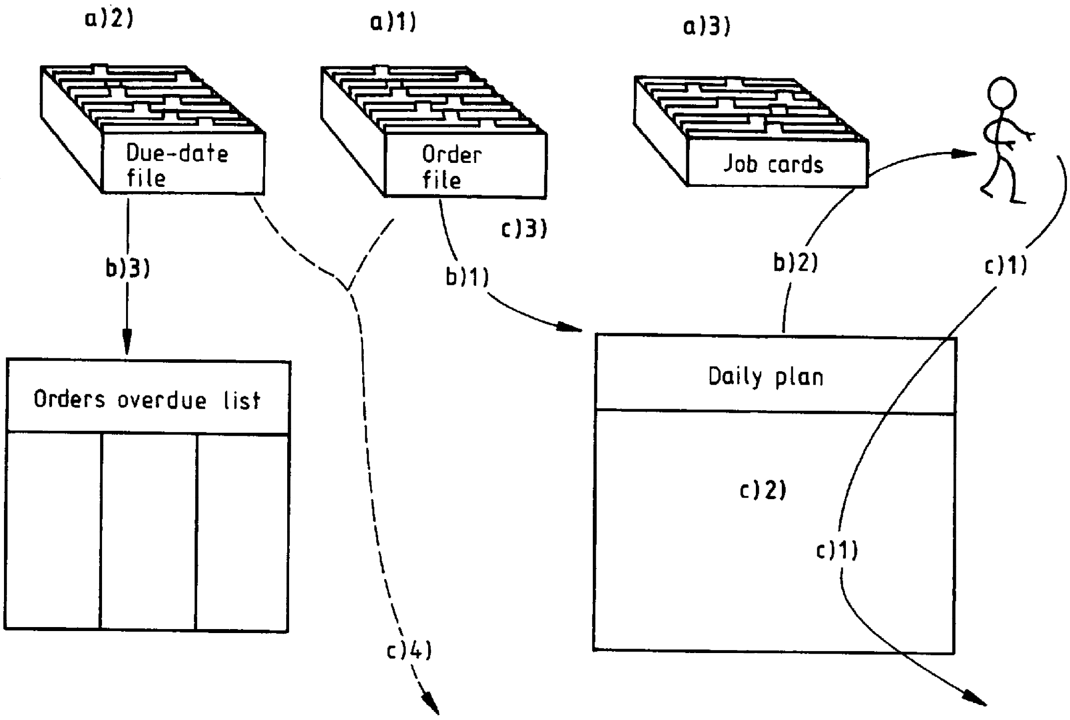
NOTE 2. The measurement of progress should be as follows.

1) Measure completion of sets if more than one part is required in the final product.

2) Allocate parts if they are used in more than one project.

3) If measuring a group of parts, record the quantity of the least available member of the group.

4) If a significant quantity is nearing completion, a ghost bar may be used. (See control point 5 in the progress chart in figure 5.)



Key

a) *On receipt of order*

1) Order filed in loading sequence against machine for first operation.

2) Due-date copy of order filed by due-date.

3) Job cards filed by part number and operation number.

b) *Daily*

1) Next few jobs listed on daily plan by the dispatcher.

2) Daily Plan shows which jobs to issue to the worker. Copies are sent to foremen, setters, storekeepers, etc.

3) Due-date file shows which jobs are overdue.

c) *On completion of operation*

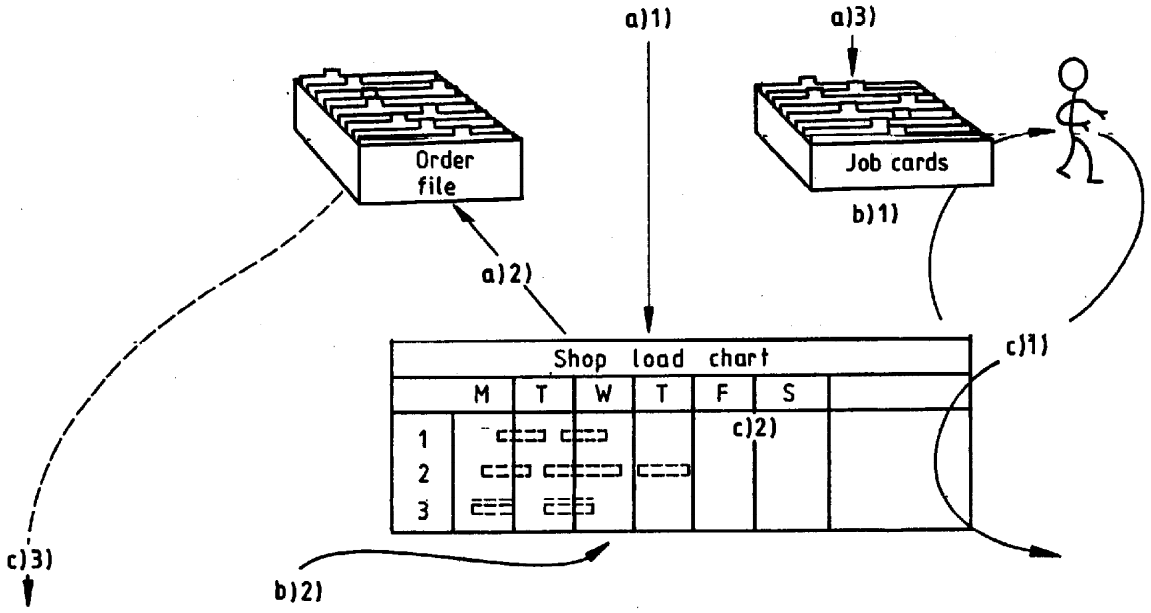
1) Worker returns job card and collects card for next job.

2) Dispatcher updates daily plan.

3) Order moved to section for machine for next operation.

4) After last operation, order and copy sent to production control office.

Figure 3. Due-date filing dispatching system



Key

a) *On receipt of order*

1) Order scheduled on loading chart.

2) Order then filed by due-date in order file.

3) Job cards filed by part number and operation number.

b) *At all times*

1) Chart shows which jobs to issue to the operators.

2) Chart shows which jobs are overdue.

c) *On completion of operation*

1) Operator returns job card.

2) Dispatcher updates chart.

3) After last operation, order sent to production control office.

Figure 4. Scheduling of system of dispatching

d) On the progress chart, plot the number of parts that should have been completed, by reference to the objective chart.

NOTE 3. Striking the line of balance should be as follows.

1) On the objective chart, starting at the date of measurement, mark off to the right the lead time of the first control point.

2) From the corresponding point on the graph, draw a horizontal like to the progress chart bar for that control point. This is the balance quantity for that bar.

3) Repeat the process for all other control points.

7.6 Shortage control

In assembly operations, a shop order documentation set consists of the following:

a) route cards;

b) operation cards;

c) bill of materials, i.e. material required.

These documents, cross referenced to work instructions and drawings, are passed to the stores in advance of the due start date of assembly for kitting. This operation allocates materials to kits in readiness for assembly and reports any shortages. A copy of the bill of materials, marked with issued materials and shortages, is sent from the stores to the progress section to inform them of the state of the kit. Shortages normally result in the raising of a shortage note, copies of these notes are held in the stores and in the progress section. As goods are received into the stores, the file of shortage notes is checked and appropriate shortages are cleared. The shortage note, suitably annotated is then passed to the progress section to update their records and on to stock control to record the goods as issued.

Incomplete kits that can be partially assembled may be released before all shortages are cleared, to reduce total overdue completion orders.

In addition to the documents above, a history card (similar to the batch identification card in **5.1**), may be raised to record the history of assembly and provide a permanent record of work completed.

7.7 Kitting facilities

A computer based production control system will enable the physical kitting of material to be undertaken at the last possible moment before issue is required, thereby maximizing the dispatcher's freedom to allocate, deallocate and reallocate material to a specific job.

If parts are common to several works orders on the schedule, due for completion within the same time frame, the dispatcher can attempt to trial kit each in turn. The system will display the quantity of each part required based on the bill of materials and the stock available. He can then identify the job or jobs that have all parts available or, by enquiring on the status of purchase and works orders, can identify the jobs with shortages that currently will have all parts available first.

When the job is issued a kit issue facility may enable the storeman to issue the kit as one transaction or to tab down the kit list identifying full or partial issue against each item. If a material is not fully issued he can specify whether or not the balance is to be issued when further supplies are received.

8 Computer based production modelling

8.1 General

Computer based modelling systems that will simulate the situation on the shop floor are available. The starting point is a file of those jobs that are in progress or due to be released in the time period that is to be simulated, details of routings including those partially complete, dependancies between works orders where applicable, the availability of machines and associated resources and the shift patterns of operatives. At each work centre there may be a queue of jobs dependent on the priority rule applying. The system will simulate the completion of the job in progress on each machine within the finite capacity available and then move it to the next work centre identified on the routing card. The job will join the queue at a point determined by its priority in relation to other jobs in the queue. In this way the jobs are moved progressively through the necessary work centres until they are complete or the end date of the simulation period is reached. The dispatcher, scheduler or foreman enquires on key statistics such as the utilization of each machine, value of work in progress and jobs being completed after the due date. He inputs changes to relative priorities, routings, work centre and resource availability and shift patterns including overtime, repeats the simulation and checks the key statistics. In this way he develops an optimum plan that achieves the most acceptable balance between resource utilization, work in progress and achieved completions.

8.2 Optimized production technology

Optimized production technology, or OPT®[1)], is the registered name given to both a manufacturing concept and a proprietary software system developed in the early 1980s.

As a manufacturing concept, this technique addresses the problems associated with the management of bottleneck resources. Traditionally, the performance of a manufacturing plant is measured in terms of the utilization of all its resources, both labour and machines. The higher the utilization the more efficient the plant is

[1)] This does not constitute an endorsement by BSI of the system.

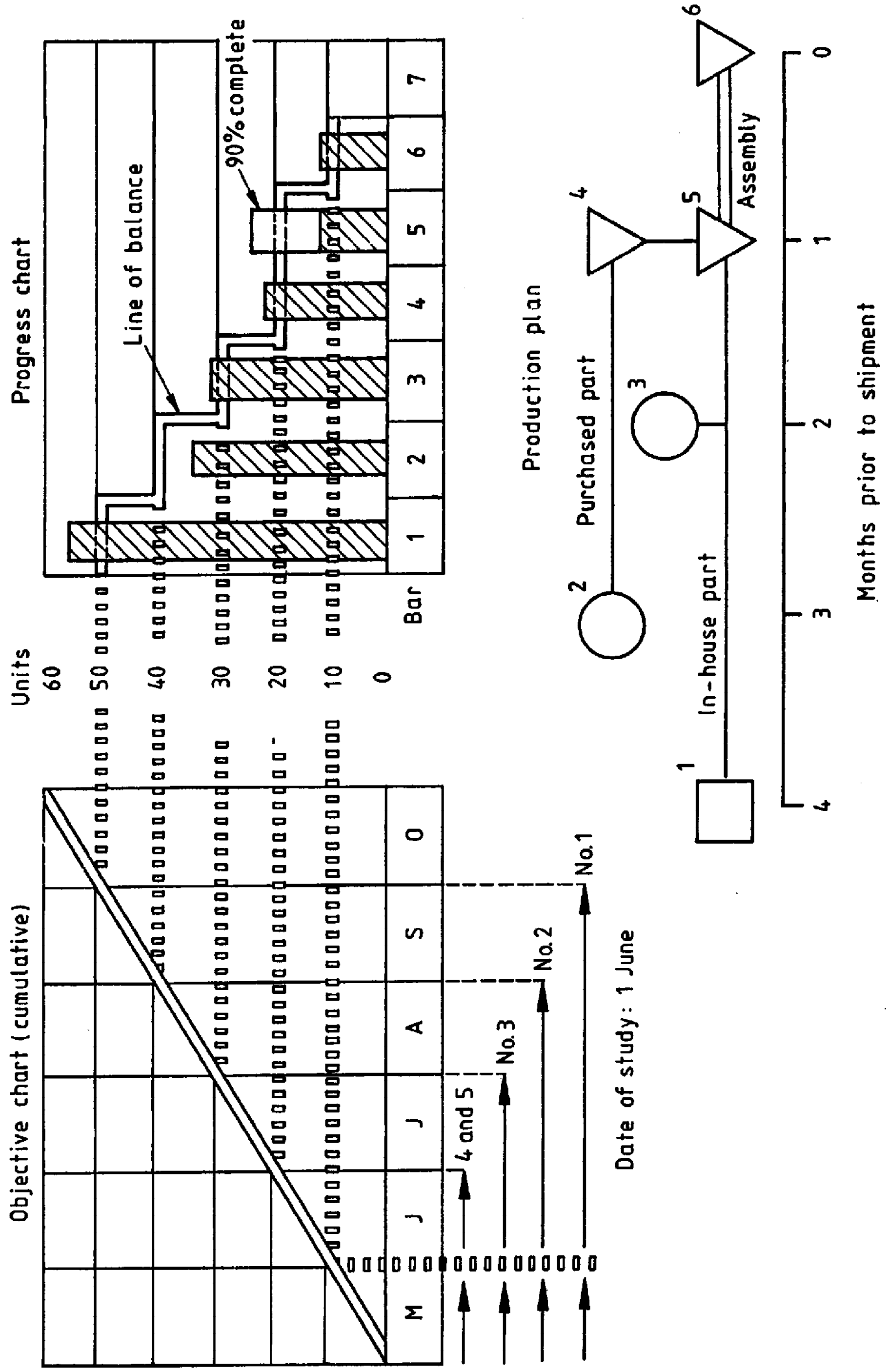
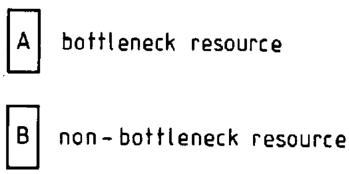


Figure 5. Line of balance

deemed to be. This means that in plants where bottlenecks exist, and very few plants are ever completely in balance, high utilization of non-bottleneck resources results in the generation of excess inventory. The excess inventory arises because the ability of the plant to convert material into saleable product is restricted by the throughput of the bottleneck resources.

The aim to balance flow, not capacity, places the emphasis on achieving maximum throughput of saleable products, not just products for the warehouse, in order to improve profitability, return on investment and cash flow.

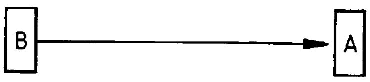
Four basic relationships have been identified between a bottleneck and non-bottleneck resource as illustrated in the following diagrams.



a) *Non-bottleneck resource downstream*

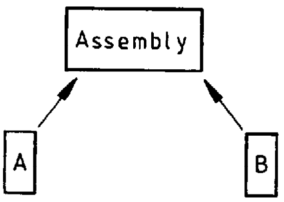
A is 100 % utilized and B is less than 100 % utilized.

b) *Non-bottleneck resource upstream*



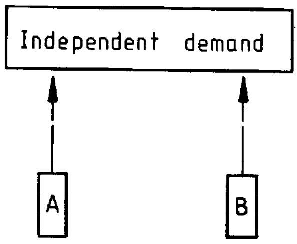
There is no advantage in utilizing B 100 % as this would only create excess inventory at A.

c) *Bottleneck and non-bottleneck resources feed a common assembly*



A is 100 % utilized. B's utilization should be less than 100 % otherwise stock will accumulate ahead of assembly.

d) *Bottleneck and non-bottleneck resources supply independent customer demand*



If stock is not to accumulate in the warehouse, utilization of B has to be less than 100 %.

Although the illustrations refer to single resources, they are clearly applicable to multiple resource situations. Thus the profitable utilization of a non-bottleneck resource is not determined by its capacity but by some other constraint in the system, i.e. demand from a bottleneck resource or from customers. A distinction is made between profitable utilization of a resource and working the resource without regard to need.

This technique challenges some of the traditional ways of measuring cost and performance. An hour saved at a non-bottleneck resource is worth nothing since it adds nothing to the total throughput of the plant, whereas an hour saved at a bottleneck resource is worth an additional hour of throughput for the whole plant. Consequently, the concept decrees that effort should be expended on maximizing utilization of a bottleneck resource. Therefore, attention should be paid to reducing set-up time, avoiding idle time by ensuring that work is always available to a bottleneck resource, and decreasing the incidence of rejects both at the bottleneck itself and downstream from it.

This technique also influences the choice of batch size. Smaller batches and more set-ups are permissible at non-bottlenecks since they reduce inventory without affecting throughput, whereas larger batches are preferred at bottlenecks in order to minimize set-up time and achieve higher utilization.

In practice, in most plants bottleneck resources only constitute a small proportion of the total resources. However, at any one time such factors as changing product mix may cause the bottlenecks to vary. In a plant with many processes and many works orders, the scheduling of work to ensure maximum utilization of bottleneck resources can therefore be very complex. The software, by using an optimizer algorithm to schedule orders and resources, aims to maximize the utilization of those resources identified as potential bottlenecks.

This technique is not an alternative to MRP, rather it enhances the performance of MRP by taking the output from MRP and rescheduling it to optimize throughput. This optimizing technique and the just-in-time technique have similar objectives in some respects, both aim to reduce inventory and maximize throughput. The technique's emphasis on reducing batch sizes at non-bottlenecks is also compatible with JIT concepts.

Make or buy decisions is another area where this technique can be used to assist management. Such decisions often depend upon capacity and the technique can help to indicate the effect of subcontracting on resources. Similarly, when bidding for new contracts, the effect of obtaining a contract on bottleneck resources can also be indicated. If the contract involves using non-bottleneck resources, then marginal costing and tight pricing may be in order, but if it involves bottleneck resources, the acquisition of costly additional capacity may well make the contract unprofitable.

This production optimization technique has its greatest impact in batch manufacturing plants with many processes. The opportunities to benefit from the concept are less apparent in flow production.

8.3 Finite production modelling (FPM)

FPM is a finite scheduling technique operating at a level of planning detail below MRP. Traditionally MRP calculates from a master production schedule the quantity and start and due-dates of part numbered items to be manufactured on the shop floor or purchased from another organization. Subsequently, for the items to be manufactured, MRP provides the data to a capacity requirements planning (CRP) module which builds up an infinite load picture by work centre over the indicated time horizon. Overloads and underloads are then manually corrected by the shop floor scheduling person by shifting work between work centres, working overtime or starting jobs earlier where capacity permitted, in an attempt to ensure delivery to due-date as dictated by MRP.

To assist in the scheduling/rebalancing of the shop floor there are computer based techniques that build up the actual maximum allowable load by work centre in any time period (finite scheduling) and shift work accordingly to attempt to smooth the load and attain the best utilization of the work centre, tool and manpower resources (modelling). FPM is one of these techniques and its purpose is to take the MRP start date and due-date view and model the best use of resources, never exceeding work centre capacity. Where work centre capacity is exceeded the model will recalculate an earlier start date using available capacity gaps revealed in the simulation. The new start date ensures that the original MRP due-date is met; but, may in fact now be an earlier than required date. This process can go through several iterations until the scheduler is satisfied that the best view has been produced. He then uses the FPM system to produce work-to lists and to write the new due-dates back to MRP.

Key aspects of an FPM system that should be available to provide full functionality are as follows:

a) the original due-date is not lost in establishing the best scheduling fit so that there is always a reference back to the original required date;

b) the rescheduling of work during simulation should recognize the dependencies of certain sequences and resources;

c) sets of resources such as people, tools, fixtures, jigs, programs and material handling should be recognized and allocated by operation and form part of the finite availability picture rather than just machine capacity alone;

d) residual scheduling should be allowed so that new and/or additional work can be scheduled into the available capacity gaps.

9 Control

9.1 Progressing

Aspects of dispatching mentioned so far have been concerned with the planning and scheduling of resource allocation. If nothing were ever to go wrong, these aspects would themselves provide full control over the manufacturing process. However, in reality there are likely to be a number of events that cause deviations from the planned programme. These may be events that affect the available capacity such as machine breakdowns, employee absences, etc. or events that affect the current load such as clerical errors, supplier failure, faulty work, etc.

The response of the system to such events will determine its effectiveness. The first prerequisite of an effective system is the ability to maintain accurate and current records of the state of progress of all orders and of the situation within all relevant work centres. The process of maintaining records, comparing actual and planned production, reporting variances and initiating corrective actions is known collectively as progressing.

Progressing takes place at a number of levels and is an inherent part of the dispatching systems previously described. The basic principle of good progress control is to concentrate on those events which are not going according to plan.

For each order that needs to be progressed (to complete it earlier than originally planned), it is likely that some other order will need to be delayed. This may be because the requirement for that order has been put back (sales department agreed that order X comes forward and is progressed and order Y goes back and is delayed) or because it is known that a component part will be late and therefore it would not be possible to meet the original date. One of the most common features of a system that is out of control is when a significant number of shop orders are due to be processed yesterday or earlier. Completing orders later than originally planned, with the endorsement of the sales department, enables the system to maintain realistic dates and these are as important to the shop floor as are accurate stock records, bills of material and routings.

Before manufacturing or assembly orders can be released to the shop floor all of those events which have to be completed first should be progressed such as the provision of drawings. This is known as pre-production progress and the progress chaser is often termed the expeditor. The purchasing department may be responsible for progressing deliveries from suppliers and the dispatcher may have the total progressing responsibility since he cannot release work until all of the materials, tools, etc. are available.

Once a job has been released the progressing of manufacture or assembly is termed works or shop progress. The progress chaser acts in an advisory role. He ensures that work is moved from operation to operation. He will report to the supervisor any delays resulting from operator absence or machine malfunction plus any departures from the schedule that will have an adverse effect on later operations.

9.2 Production records

A production recording system is essential to monitor progress and provide feedback to the production control section. Such recording can be simple end-of-shift verbal reports or sophisticated on-line monitoring of flow-line production. The success of a control system is dependent on the quality and speed of the feedback provided and in process control activities fast, accurate reporting and response (as facilitated by on-line control mechanisms) is essential.

It is also useful to maintain statistical records of performance such as percentage of orders completed by due-date. This emphasizes the need for following production plans diligently and if such records are transferred to charts they can provide fast, visual confirmation of performance.

One of the simplest recording systems is a document for each shop order which lists all operations to be performed and reports the completion of each operation. This record can be made on the route card accompanying the batch of work although this makes it difficult to check on orders from a central point.

Due-date filing dispatching provides a copy of all current orders in due-date sequence. Orders are removed from the file as they are completed. A quick check shows which orders have not been completed by their due-date and by how much they are overdue.

Where shop loading has been done using a shop load chart, the progress may be recorded on this chart against the scheduled loading.

In the absence of (or to complement) formal systems, progress chasers are often employed to walk and count, i.e. to walk round their own sphere of activity and record progress themselves.

When it is apparent that events are deviating from the planned programme, a mechanism should exist for taking corrective action and for modifying the future short term schedule. One common method is to hold a daily meeting where the previous daily plan is considered and any recovery actions are discussed. The current daily plan can then be modified to accommodate any required changes. If dispatching is carried out effectively, such short term modification should have little effect on the longer term production programme. This is especially true where the current plan includes contingency plans for overtime working, subcontracting, reallocation of machines, etc. in readiness for such situations. In continuous flow production industries, deviations from planned resource allocation may be much more serious than in batch production. Thus plans for dealing with capacity uncertainties (breakdowns, absences, etc.) should be part of the longer term planning process.

9.3 Input/output control

Input/output control is a technique for monitoring load in a work centre. It involves recording the value of the orders released into a work centre and the value of the orders completed, partially completed or cancelled in the work centre over a period of a day or week. The difference is the amount of work-in-progress remaining in the work centre. Table 1 is an example of an input/output record.

Value is normally expressed in standard hours but can be in any convenient unit of measure, e.g. mass, size, number of items, so long as input and output values are expressed in the same unit of measure. It is not permissible, for example, to record input in standard hours and output in actual hours.

Recorded input and output figures may be monitored against planned inputs and outputs. For example, it may be planned to release 500 standard hours of work into a work centre each week, but actual standard hours released may fall below this figure for a variety of reasons, such as delays upstream from the work centre. On the other hand, if planned input figures are being achieved, a shortfall in a recorded output compared to planned output is indicative of hold-ups in the work centre.

The amount of work-in-progress in a work centre can also be monitored using the input/output technique. It is usually possible to determine from experience the level of work-in-progress that a particular work centre should hold in order to achieve the desired compromise between high utilization and short throughput time. Work-in-progress in excess of this level will not achieve greater utilization but will almost certainly increase throughput time. If on the other hand, work-in-progress falls below the level, throughput time may decrease but utilization will fall.

If the input/output record shows a growth in work-in-progress above the desired level, action should be taken to bring it back to that level. Some examples of action to be taken are as follows:

a) withhold release of new orders into the work centre until work-in-progress returns to normal in order to prevent loss of control, congestion and loss or damage to work already on the shop floor;

b) check that the capacity figure used for planning is not greater than that actually being achieved. If it is, either amend the planned capacity figure or endeavour to increase capacity, for example by improving manufacturing methods, transfer of staff from under-utilized sections, overtime or shift working, or subcontracting.

Input/output control is a very simple and effective way of monitoring load in a factory which has a number of work centres. It enables attention to be focused on areas where results are deviating from plan and where overloads are occurring.

9.4 Computerized techniques for control

9.4.1 *Shop floor data collection terminals*

If the works orders are held as a computer file and the orders are updated against shift reports or completed operation cards, for example via a terminal in the supervisor's office, then it is possible to interrogate these details on line. By inputting a works order reference the progress to date against that order in terms of quantities of product completed; operations still to be completed and targets should be displayed. Similarly by inputting a work centre reference the list of jobs still to be processed by that centre should be displayed, including the quantities and times.

There are terminals available that are sufficiently robust to be sited on the shop floor. The operator will identify himself by means of a bar code badge or by entering a password, identify the job by entering the works order reference or inserting a pre-punched operation card or reading a bar code on the operation card and then entering the quantity. The software controlling the terminals should undertake simple checks such as whether the job exists, the previous operation has been reported and the quantity does not exceed that reported at the previous stage. It will retain the details until the processor can accept them.

Shop-floor sited terminals can be used for recording attendance and departure of personnel or specialized terminals may be used at a clock in point. If the time and attendance system and job booking system are integrated, as well as recording total attendance for payment, job progress and time spent on each job, the supervisor can receive a statement of non-productive time.

9.4.2 *Automatic status recognition*

The status of specific parts or orders has traditionally been monitored by the use of manual job cards or by manual input of production data into a production control computer system. The present trend is towards automatic input of this information from the operations of equipment and processes within the developing field of advanced manufacturing technology (AMT).

Table 1. Example of an input/output record

Work Centre No. 234
Report at Week Number 9
All values in Standard Hours
Planned level of WIP 500 Std. Hours

		Week number				
	B/F	4	5	6	7	8
Planned input		500	500	500	500	500
Actual input		510	490	470	510	510
Cumulative deviation	−10	0	−10	−40	−30	−20
Planned output		510	500	500	500	500
Actual output		500	480	510	520	510
Cumulative deviation	−30	−40	−60	−50	−30	−20
Work-in-progress	510	520	530	490	480	480

Any piece of production equipment, including handling systems, can be designed to recognize parts or products in an increasing number of ways, from bar code labels to automatic shape recognition. As this ability improves in detail, the ability to automatically monitor the progress of parts or orders through the production process also improves. This improvement in detail and accuracy enables better control to be exercised and becomes more important in fast moving production environments operating with minimum stock levels and work-in-progress under JIT concepts.

9.4.3 ***Backflushing***

Closed loop systems, such as MRP, require that every order that is opened in the system is followed in due course by a transaction to close it, either on completion or cancellation.

Anyone who has run an MRP system will probably be familiar with the situation where orders remain open long after the products they refer to have been completed and delivered. As a result, control reports become misleading and the system loses credibility. To investigate these orders and close them can be a time consuming and difficult chore. The reasons why open orders are not closed when they should be are many, the obvious one being poor shop-floor discipline that fails to notify that an order has been completed. Another very common reason is that the bill of materials which the MRP system uses to create open orders contains levels that do not exist in practice on the factory floor, i.e. the process is continuous without a control point. As a result, the system creates superfluous orders. This can be overcome by restructuring the bill of materials so as to eliminate the unnecessary levels.

Elimination of intermediate levels can of course lead to some loss of control over work-in-progress, but where the manufacturing lead times are short this may not be significant. Indeed, in a fast throughput environment such as the one that occurs in flow line manufacture where the total floor time is generally no more than 3 days, it is often feasible to transfer purchased items directly from the receiving area to the production line without putting them into store. Likewise, manufactured items can go direct from the production process to the production line without passing through a work-in-progress store. In this way, materials handling and storage are reduced and administration becomes less complex and costly.

At some point, however, the items consumed have to be deducted from inventory and accounted for, and this is performed by a technique called backflushing.

Backflushing is a method of deducting stock from inventory after issue. It involves, first, exploding the bill of material for an assembly or product and multiplying the quantity of each item in the bill by the number of assemblies or products completed (and scrapped) during a specified time, e.g. half day or day. Secondly, the quantities of the items obtained are deducted from inventory and from open orders. The technique demands that bills of material are completely accurate since any differences between a bill and what is actually used will result in the occurrence of cumulative shortages and surpluses.

Backflushing can be made to function at one level in the bill of material (single level backflushing) or through all levels to the lowest (purchased) level in which form it is known as superflush.

List of references (see clause 2)

Normative references

BSI standards publications

BRITISH STANDARDS INSTITUTION, London

BS 3138 : 1992	*Glossary of terms used in management services*
BS 5191 : 1975	*Glossary of production planning and control terms*
BS 5192 :	*Guide to production control*
BS 5192 : Part 1 : 1993	*Introduction*

Informative references

BSI standards publications

BRITISH STANDARDS INSTITUTION, London

BS 5192 :	*Guide to production control*
BS 5192 : Part 2 : 1993	*Production programming*
BS 5192 : Part 3 : 1993	*Ordering methods*
BS 5192 : Part 5 : 1993	*The relationship between production control and other managment functions*
BS 5192 : Part 6 : 1993	*Computer aided production control*

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