UNIT 3 PROCESS SELECTION

Objectives

After going through this unit, you should be able to:

- identify the various tradeoffs involved in process selection
- know the issues involved in the general transformation process selection procedure
- learn the four forms of transformation processes-their characteristics, advantages and disadvantages
- know about the new technologies that are applicable to the transformation processes
- understand the concept of Process Life-cycle
- learn the use of break-even analysis in choosing the least cost process
- appreciate the need to maintain focus in all production operations.

Structure

3.1 INTRODUCTION

The transformation process that converts inputs into outputs with added value is the core element in the operations function. The selection of the process is therefore a strategic decision for most organisations. The process selected will, to a very large extent, determine both the quality and quantity of men and women to be employed as well as the amount of capital required for the production of goods and services. In fact, many organisations are slowly coming round to the view that operations has been the missing link in the traditional approach of formulating a corporate strategy wherein the production or operations function is expected to play a supportive role to marketing.

Undoubtedly, marketing has to establish what is to be produced to satisfy the needs of the customers. However, the traditional approach is partly based on the view that "PRICE = COST +PROFIT". Looked at this may, the price of a product or service is obtained by adding a profit element to the cost incurred in producing the same.

This view of looking at profit and price may not have any serious problem if the environment is less competitive. But as markets become more competitive,, the customers have more choice in terms of product attributes like design ,functions, ease of use, performance, quality and cost.

The transformation process, therefore, has to be so selected that it can provide the desired product attributes and at the same time remains cost-effective. This can be best achieved by taking a strategic view of the production/operations function and by integrating the operations function including process selection while formulating the corporate strategy of the firm.

In this unit, we shall discuss the major factors involved In the selection of the transformation process, the various alternative process forms available and the process involved in selecting an appropriate transformation process.

Process Selection as an Adaptation

The major considerations in any process selection e.g. capacity, flexibility, lead time, efficiency in using resources are so interdependent that changing the process to alter one will almost invariably alter the others as well. There are numerous tradeoffs available while selecting a process-between different materials, between requirements of labour and capital, between volume and variety, between cost of production and flexibility and so on. It is important to know the consequences of every such tradeoff.

The transformation process selection is a complex decision because of the existence of so many tradeoffs, many of which are also interdependent. Generally speaking, there is no concept like the best process for a particular conversion. Rather, many times it is an attempt to find a process which produces acceptable levels of attainment on many objectives some of' which are incongruent. For example, we want a process which is flexible as well as instrumental in producing outputs with least cost. Obviously, we cannot have both and so our attempt will be to select a process which has acceptable levels of flexibility and cost. One can give similar examples from the other tradeoffs mentioned earlier. Such a situation only highlights the need, to integrate these decisions while formulating the corporate strategy of the firm.

By now it should be clear that any change in the host of factors mentioned above will have a profound effect on the process selected. For example, with the passage of time, if the volume or the variety of the products/services produced undergoes a change, a different process form might become more appropriate. Therefore, the process selection' continues to remain an adaptive process.

Process Selection and the Environment

As a strategic decision, the process selection decision is influenced by the environment to a very great extent. With newer materials are becoming available such as a different transformation process which might become more appropriate. This phenomenon can. be seen very clearly wherever plastics are being used as newer substitutes of some natural material. Metal containers giving way to plastic containers mean a totally different transformation process for the company manufacturing containers. New synthetic packaging materials have caused significant changes in the process involving packaging of consumer products.

Similarly, development of new technology may render a process obsolete as the new technology is more economical, uses cheaper material or produces goods with a higher quality level. Bolts can be made by machining hexagonal rods. However, with the development of cold forging, the material wastage involved in metal cutting can be totally eliminated giving rise to a process which is not only more economical but faster as well. Not only the manufacturing technology, but the technology involved in organising the operations function also has an effect on the process selected. This can be seen when concepts like Group Technology or Autonomous Working are used and we shall discuss these concepts later in this unit.

The competitors might also affect the process selected for a transformation. For example, when the competitors can deliver the product or service much faster than us, this may lead to a review of the form of process selected for our operations function. Similarly, when we want to compete on non-price factors.like quality. custom-made product designs, shorter lead times or easier availability, the transformation process has to be geared to the combination of such factors that we consider to be important.

3.2 FORMS OF TRANSFORMATION PROCESS

Process selection is actually a generic decision and in practice this refers to the selection of sub-processes and sub-sub-processes depending on the type of output that is produced. If the output is. a product then, following the design of the product, this can be broken down into sub-assemblies and sub-sub-assemblies till we reach an elemental level of components which cannot be broken down further. Now, for each of such components we have to decide whether to produce it ourselves or to buy from outside. If it has to be produced by us, then the process selection decisions concern the technology to be used, the sequence of operations to be performed, including in process storage and transportation from one work centre to another, equipment required for the transformation, staffing, the detailed work place layout, design of special tools, jigs and fixtures and so on. If the product requires an assembling of components and sub-assemblies, then the assembly process has also to be selected and designed appropriately. In fact, there may be no best way to produce a product or service; rather it may always be possible to improve both the output and the process selected to produce it.

Establishing the Volume and the Variety

One of the major considerations for process selection is knowing where we want to peg our organisation on the volume/variety continuum. The volume/variety continuum can be conceived of as an imaginary straight line, one end of which refers to very high product variety implying each product to be different from each other, consequently having very low volume viz., only one of each product. As we shall see later in this unit, such high variety requires the use of highly skilled labour, general purpose machines and in general, detailed and complex operations, planning and control systems.

The other end of the continuum refers to very low product variety implying a single standard product that is produced in very high volumes. Such a combination enables us to use highly automated, mass production processes using special purpose machines and simple production planning and control systems.

Produce-to-stock or Produce-to-order

A related consideration for process selection is whether the product is to be produced and stocked in our warehouses to be sold as and when the demand occurs, or is to be produced only on receipt of an order from the customer. It is a related consideration because, usually standard products with less variety are produced in batches and as sales proceed, we draw the products from the inventory. When the inventory level - touches a predetermined minimum level, a fresh batch of the product is produced and such a cycle goes on. In this system, goods are produced in anticipation of sales orders and the customer gets immediate delivery and does not have to wait. However, such a system can work only with inventoriable products and the shorter the shelf life of a product, the higher the risks undertaken by the producer. For example, newspapers have a very short shelf life and so the risks of overproducing as well as underproducing are high.

When we produce-to-order, the production process starts after receiving the sales order in quantities dictated by each sales order. All custom-made products are produced-to-order since the exact specifications are known only after receipt of the order. In such a system the customer has to wait while his products are being produced and so the longer the lead time for production, the longer the waiting period.

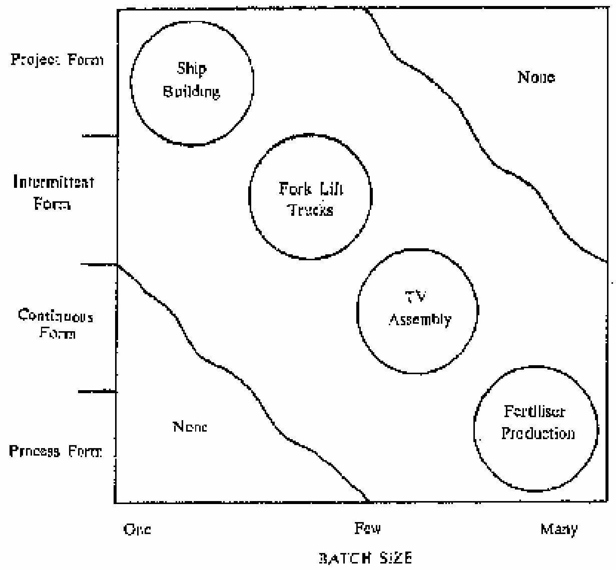
Services, by their very nature, cannot be inventoried and so services have to be. produced to order. The transformation process in such a system has to be so selected and designed that the waiting time for a customer is not excessive.

Finally, we can have a combination of both these systems as well. For example, where a large number of options are provided on the product, the components and .sub-assemblies might be produced to stock whereas the final assembly is carried out on order. In restaurants, food is semi-cooked in batches i.e. produced to stock and the final dish is prepared on receipt of a customer order i.e. produced-to-order.

Effect of Output Characteristics

In the previous sections we have said that the form of the transformation process depends to a large extent on output characteristics like volume/variety and whether produced-to-stock or produced-to-order. Figure I illustrates these comments by showing the relationship in a diagrammatic form.

Figure I : Effect of Output Characteristics on The Form of Transformation Process



Source : Adapted From Hayes, R.H. et al., "*Link Manufacturing Process and Product Life Cycles,*" Harvard Business Review, Jan-Feb, 1979

The horizontal axis which shows the output characteristics is represented in terns of the batch size. On one extreme we have products produced in batches of size one, i.e. each product is different from the other. On the other extreme we have products produced in infinitely large batch sizes. These are products with, no variety and have the characteristics of a commodity like fertiliser, sugar, cement etc.

The form of transformation process is similarly represented on the vertical axis. The top end represents the project form where each project is followed by another project- no two projects are exactly alike and detailed planning, scheduling and monitoring has to be performed to keep the project costs and durations under control. As we go down the vertical axis the flow of materials becomes more smooth and uniform. These can be categorised as batch production or interrupted form, mass production or continuous form, and finally, as the name implies the processing form wherein there is no interruption in the flow of materials at all, as in a petroleum refinery or a fertiliser plant. In the subsequent sections we are going to discuss each of these process forms in somewhat more detail.

However, we would like to point out a couple of things in Figure I before we proceed further. First, as is shown in Figure 1 we would not find any process corresponding to the lower left hand region or the top right hand region of the Figure.. That is to say, when the batch size is very small it is not at all advisable to °use the continuous or the processing form of transformation. Similarly, when the batch size is really, large, it is again inadvisable to use the project or the interrupted form.

The second point that emerges from Figure I is that for any batch size, there is usually a choice available in choosing the processing form. Thus, even in the same industry one may find different competitors using different processing forms and thus trying to create a special niche for themselves. For example, one manufacturer. of ceiling fans might choose the interrupted form whereas another might decide to adopt the continuous form of production and both might coexist in the same competitive market. .

It is also not difficult to see that Figure I also holds good for services (except that there is no processing form for service). The service provided by a lawyer on a law-suit is almost always of a project form. Services provided by a government agency

is usually of the interrupted form whereas for some high volume services the continuous form is employed. In fact, in recent years, as the service sector is growing faster than other sectors, more and more services are gradually being pushed down the vertical axis of Figure I. Fast food service is a typical example of this phenomenon.

3.3 THE PROJECT FORM

Project operations are characterised by complex sets of time-bound activities that must be performed in a particular order. Distinctly different from all other forms of transformation process such that each project has a definite beginning and a definite completion, the project form of transformation is very useful when complex tasks involving many different functional specialisations have to be performed against strict deadlines.

If the output of the transformation process is a product, such products are generally characterised by immobility during the transformation. Such operations are referred to as Fixed Position assembly and can be seen in the production of ships, aircrafts, and construction of buildings, roads, etc. As projects have limited lives, a project team is usually set up to manage a project. Resources such as men, materials and equipment are brought together for the duration of the project. Some materials are consumed in the transformation process, while others like equipment and personnel are redeployed for other uses at the end of the project.

We give below a small list of projects to clarify our understanding of a project:

- setting up a new thermal power plant
- building a hospital
- modernising a textile mill
- constructing roads, bridges, buildings
- organising an annual sales conference
- launching a new product
- punching and delivering a programme like Diploma in Management
- computerising the purchase and the inventory control system
- conducting a two-week training programme.

The number and importance of project operations is growing at a very fast rate in most societies, including ours. We shall now discuss some of the possible reasons for this growth in project operations. The benefits from various development programmes are delivered through projects. With the spread of education and rise in income levels, people themselves organise projects in the areas of community development, travel and tourism, social functions etc. Each knowledge area is getting more and more specialised and on many jobs we now need inputs from different specialisation areas. The project form is very suitable to handle inter-disciplinary specialist groups.

The fast-pace of technological developments is forcing many companies to adapt to the new technologies. Such developments are taking place not only in the manufacturing technologies but also in packaging technology, material handling technology, computer technology and so on. Implementing a change is usually carried out through a project operation. Increased competition, similarly, is forcing companies to launch projects on cost reduction, higher productivity, better methods and so on.

Whenever a transformation process is to be carried out under severe time and cost constraints, i.e. whenever the penalty associated with time and cost over-runs is severe, the project form of transformation is the most suitable. With ever-higher prices of equipment and labour, the cost of delay in many activities is becoming intolerably high and that is another reason for the speedy growth in project operations.

Choosing the Project Form

There are many situations in which the project form of the transformation process is the most appropriate. Obviously, if the tasks involved are for a limited duration, there is perhaps no alternative to using the project form of operations to carry out the tasks within the time frame prescribed.

The project form also offers extremely short reaction times to changes-both internal and external. Thus, if the outputs belong to high technology areas where the product design and/or the process technology is changing at a very fast pace and the operations have always to be kept abreast of the latest developments, again the project form may be found useful. For example, the project form of operations is used very often when we are selling chemical plants.

When a transformation process requires inputs from many specialisation areas, the project form of organisation is known to perform well. This is because the project form draws upon a mixed complement of personnel from different functional specialisations (e.g. mechanical engineers, civil engineers, chemical engineers, technicians, marketing and financial specialists etc.). However, the same feature of mixed complement of personnel does not allow the project form to advance high technology areas. Another process form where operations are organised by functional specialisations may be more appropriate if advances in high technology areas is one of the desired objectives. In the latter form, a group of specialists help in developing a process related to their field of specialisation. Such a group usually has access to specialised manpower as well as equipment which also contributes towards advancing technology. In the project form, generalised resources (staff and equipment) which are usually used as specialised resources will have a poor utilisation.

When the tasks involved are of very large scale involving many inter-dependent activities, the project form of operations is typically chosen. This is because the project form is better suited for detailed planning, monitoring and control of a large number of inter-related activities many of which are performed by different agencies.

Activity A

Can you choose an area or activity in your organisation where project form of organisation may be more suitable compared to existing organisational form?

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Characteristics of Project Processes

Project operations are different from other forms of transformation process in the way resources are organised and deployed as also in the planning and control of various activities that constitute the project. In the following sub-sections we discuss some of these characteristics of project operations.

Short Life-cycle

Projects are designed to have a definite beginning and a definite end. Project processes are therefore different from all other forms of transformation processes in that they have a specific completion. At the end of one project, resources from this project could be redeployed elsewhere in other project processes or other operations. In fact, even during the life of a project, resource requirements. are not uniform. Thus in the initial phase, resource requirements including manpower, are at a low level. But there is a fast build-up during which more and more resources are absorbed in the project. This build-up, however, gradually levels off and then there is a cutting back as the project nears its completion. However, the resource requirements in terms of a particular skill (e.g. design engineer, high pressure welder etc.) or a particular equipment (e.g. concrete mixer, pile driver etc.) may vary more unevenly and so resource levelling remains one of the major difficulties in project planning and scheduling.

Consequent Personnel Problems

This phenomenon of a fast build-up, a levelling off and final cut back in resource requirements can give rise to two related personnel problems.

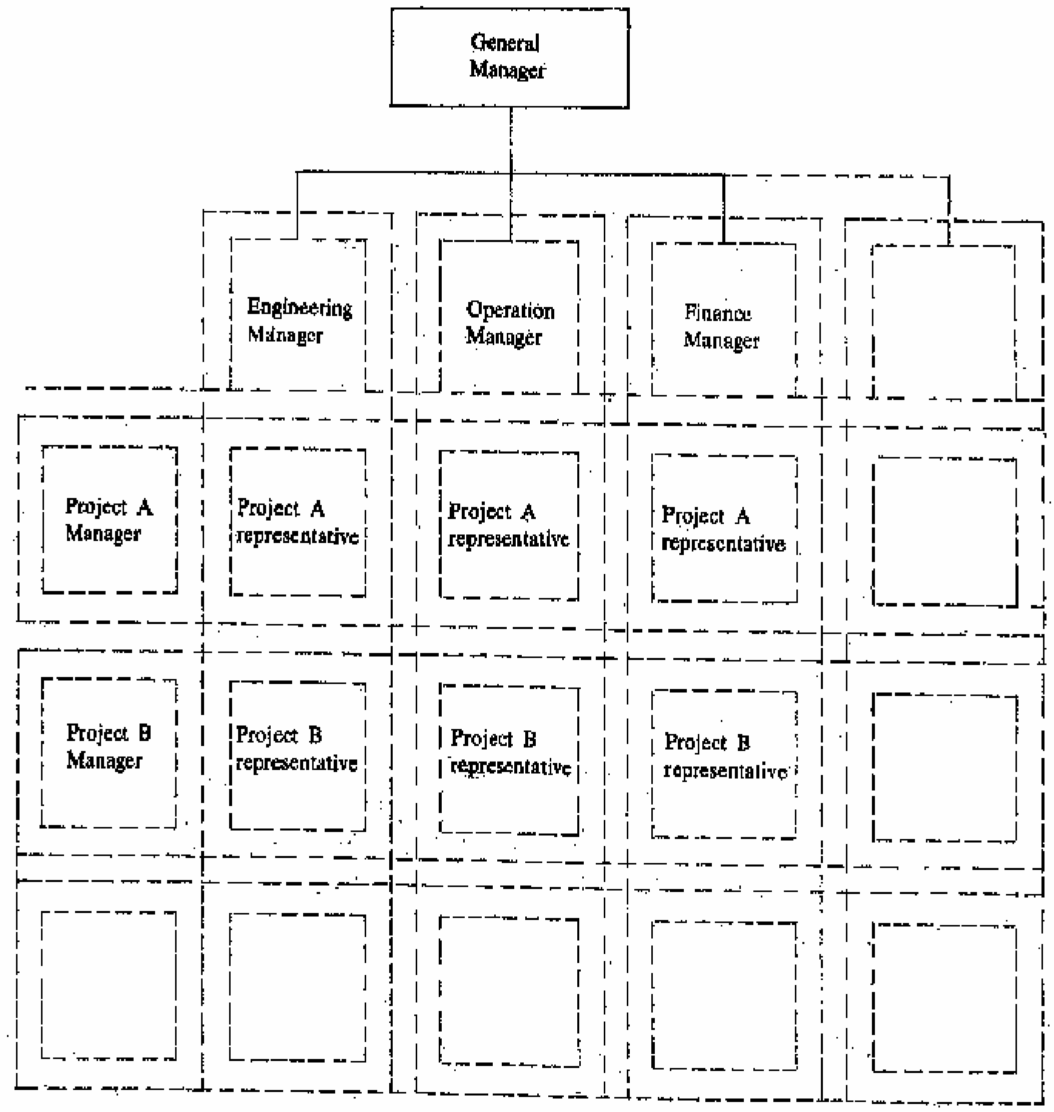
When there is a fast build-up, staff is generally borrowed from other departments and also some are hired for a short durat on. Thus, they may have limited loyalty and short-lived interest in the project. This is further compounded by the fact that the staging area or the site for many projects could be in a different and relatively undeveloped geographical region and that causes some dislocations in the normal life of the persons involved. Finally, the persons may have limited experience with the special tasks involved in the project.

As each project has a limited duration and as the end of the project draws near, the staff may start spending more time getting prepared for the next job. This is especially true if they are hired for the project and have to look for alternate jobs once the project is over. In the process, the project may get dragged beyond its scheduled date of completion.

Matrix Organisation

When multiple project operations are. under way, a matrix organisation structure is generally used. In a matrix organisation, project representatives for each project are designated by different functional areas. As shown in Figure II there are project representative from Engineering, Operations, Finance and so on for Project A. There are similar representatives for Project B and other projects. Thus, each functional manager holds the resources and each project manager coordinates the use of designated resources through the project representative concerned. This form of organisation allows coordination across functional departments for better use of resources. However, a major disadvantage of this form of organisation is that an employee has two supervisors-one in the project and another. in his "home" or functional department. The need for coordination between functional and project managers is essential so that there are no contacts in regard to questions such as: Who will evaluate and reward employees? Who is ultimately responsible for the discipline of employees? In the absence of such coordination the project representative may find himself or herself in the unenviable posit ion of having to satisfy two bosses with different priorities.

Figure II: Matrix organisation structure for project management



Activity B

In your experience, have you come across Matrix form of organisation? From experiential point of view, what are the advantages and disadvantages. Identify some situations where Matrix form would be useful.

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Activity C

Think of a project to which you belonged or you have observed from close quarters.

Recall some important characteristics of that project.

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Importance of Scheduling and Control

A project generally involves many tasks-each having its own specialisation and perhaps to be executed by a different agency. However, they have a strict precedence requirement-like one task cannot even begin until two other predecessor tasks have been completed. The cost of delay in completion of the project is also usually very high, many times with explicit penalties being mentioned as well. Because of all these reasons the scheduling and control of various activities in a project assumes great importance. Some network planning techniques like CPM and PERT have been specially designed to resolve these. issues.

3.4 INTERMITTENT FLOW PROCESSES

When the output variety is large, each output takes a different route through the organisation, uses different inputs, requires different operations and takes a different amount of time and also sequence, the intermittent form of processing is often used. In this system, each output, or small group of similar outputs (referred to as a batch or a lot), follows a different processing route through the facility, from one location to another. The facilities are organised around similar operations functions. For' example, in an engineering organisation there is a foundry, a machine shop, a press shop, a tool room, a paint shop and so on. In a hospital, there is a blood bank, an X-Ray department, a pathological laboratory and so on. The flow through these departments depends on the exact needs of a patient. The intermittent process is especially suited for service organisations because each service is often customised and so each one requires a different set of operations in a different sequence...

Characteristics of the Intermittent Form

Referring to Figure I, the intermittent process form is generally suitable when the variety is large and consequently the volumes are low. The transformation process should be able to take care of this large variety and also in a manner that the cost of the processing is not excessive.

Flexibility

When an organisation wants to produce a variety of outputs using common facilities, it wants to have flexibility in its operations. This is achieved by employing general purpose machines and equipment as well as having staff with a wide range of skills. The facilities are laid out in accordance with the general flow and for specific outputs, there may be a lot of movement as well as backtracking depending on the sequence of operations required. Not only the processing, even the inputs required , for different outputs could be quite different.

Even if the final product does not have excessive variety, e.g. in manufacturing of typewriters, the intermittent form is still used for the manufacture of components. This is because a large number of components are assembled into a typewriter and the same facilities could be used in making many different components in batches. One batch of 1000 pinions could be produced this week and the next batch may have to be produced only after one month. By splitting into batches in this manner, a large number-of different components can be produced on a common set of machines. All this is possible because the intermittent form of processing is flexible.

Around Standard Operations

The transformation processes are organised around standard operations in the intermittent form. In a bank, this would result in departments like cash, advances, deposits, savings bank accounts and so on. Any customer, who wants to deposit or withdraw cash, has to go to the cash department for this purpose.

In such a scheme, each functional group is a specialised group and performs all tasks connected with that specialisation. That is why the workers need to have a width of. skills so that they can perform a range of tasks-of course within the specialisation. A machine operator in a grinding shop will not be producing the same output everyday and thus besides skills in operating different types of grinding machines needs the ability to read and interest blueprints and perhaps also the ability to `set up' grinding machines to perform different jobs.

The amount of specialisation achieved by organising around standard operations enables the organisation to solve complex and specialised problems. Thus, a difficult grinding job is more likely to be carried out by an organisation having a grinding shop than by another having project operations or even continuous flow processing where grinding operations are also being performed.

Material Handling and In-process Inventory

As the grouping of facilities is around standard operations, the partly processed output is to be transported from one standard operation to another. The amount of material handling for an output or a batch of output depends on the number of standard operations to be performed and also the distance between the locations where the operations are performed. For all the outputs of the organisation, therefore, the amount of material handling would depend on the output mix and the layout of different, facilities. A great deal of effort is made to design the facilities layout so that the material handling is reduced for a targeted output mix.

Again, as the same facilities are being used for the processing of many outputs, the flow of materials through the facilities is not smooth, but interrupted. After one operation, the partly processed output or batch of outputs may have to wait if the facilities required for the next operation are busy on the processing of another output on batch. Such material is referred to as work-in-process and the consequent in-process inventory is typical in intermittent flow processing.

Difficulty in Management of Resources

Since each output or batch of outputs is different, the planning and control of the operations function is very difficult under intermittent flow processing. Elaborate planning and control procedures are used so that the movement of each output or ;r batch of outputs can be tracked and all the inputs required for a particular output or batch be made available in time. The planning and control becomes more difficult in the absence of accurate time standards as the outputs may not be repetitive.

Advantages of the Intermittent Form

In transformation processes, there is always a trade-off between flexibility of operations and the efficiency of use of resources. Intermittent transformation processes are chosen whenever flexibility is considered more important than mere efficiency.

Variety at Low Cost

The intermittent form of processing is appropriate when we want to respond to demands of small volume and high variety. The primary advantage of this form of processing is, therefore, the ability to produce. a wide variety of outputs at a reasonable cost.

The choice of machines and equipment, the skill of the staff, the layout of the facilities and 'all related decisions emphasise the need to have flexible operations which are also not very costly. In intermittent flow processing, general purpose machines are generally used as these are cheaper than special purpose machines, since they are in greater demand and generally available from more suppliers. Also, they are easier and cheaper to maintain and dispose of thus reducing the cost of obsolescence. Because of the diversity in outputs, all the equipment does not have hundred per cent utilisation. The cost of unutilised equipment is low, as the equipment is simple general purpose and not very costly.

High Capacity Utilisation

As facilities are grouped around standard operations, all the outputs requiring a particular operation will have to be. sent to the section carrying out that operation. Thus, there will be a high capacity utilisation for equipment grouped around that operation. The cost involved in providing-special environmental conditions for some operations e.g. airconditioning, dehumidifying,. dust proofing etc. is also minimised as all such equipment is physically close to each other-when the organisation is laid out for intermittent form of processing.

Staff Advantages

Each worker performs a complete operation under intermittent processing-e.g. completing an analysis on a form, painting a component or product etc._ This, , complemented by the fact that the task itself is not repetitive, provides the workers pride of workmanship and increased responsibility. There is usually a high morale in the group when all the group members are similarly skilled and work in the same . location.

Disadvantages of the Intermittent Form

The intermittent form will not remain the best form of processing if the volumes for some outputs become high. The in-process inventories could become excessively high and the operations planning and control could get out of hand necessitating the use of expediters.

More Costly for High Volumes

The initial cost for general purpose machines, which are mostly used in intermittent processing, is low. But they are usually slower than special purpose machines and also give lower quality of outputs. The skilled operators are paid more than the semi-skilled or the unskilled, The end result being that although the fixed costs are lower for general purpose machines, the variable costs per unit of output are higher. For . low output volumes, therefore, the general purpose equipment could be the cheapest as well. However, as output volumes rise, the advantage in terms of a lower fixed cost n is more than compensated by a higher component of variable cost and thus the special purpose machines may offer the least cost alternative.

Complex Operations Planning and Control

As mentioned earlier the planning and control of operations is very complex

for the intermittent form. When the number of jobs on the ship floor rises to high , levels, it becomes almost impossible to keep track of individual jobs. Over and above the paperwork involved, "expediters" are employed to reorder priorities and stack down specific jobs.

The requirement of each output being different, in the absence of such detailed planning and control there may be production bottlenecks on some facilities whereas resources may remain idle at some other facilities. It is easy to see that there may be a host of reasons causing such idling of resources-e.g., machine breakdown, raw material non-availability, delay in a previous operation, absent worker, non-availability of tools etc. etc. It is the job of operations planning and control to ensure that all the inputs required for a particular operation are made available when the operation is planned.

Large In-process Inventory

Intermittent processing would always have some in-process Inventory. However, as the variety of outputs and the scale of operations increase, the in-process inventory becomes larger. On top of it, there will be a fast build-up of in-process inventory if there is any laxity in the operations planning and control function. This increases the space requirement of operations and also disturbs the appearance of the operations area at times making it even unsafe.

The material handling equipment used in intermittent operations is generally mobile and is. more expensive than the fixed position handling equipment like chutes and conveyor belts. It also requires more space for movement thus adding to the space requirement.

New Technology for Intermittent Flow Operations

There have been quite a few developments towards increasing the efficiency of intermittent flow operations. Many of these developments are based on using the computer for many planning and control activities and some, like group technology, are based on using continuous flow principles for outputs which have a large variety.

Computerised Production and Inventory Control Systems

Many different types of computer packages are available which can link the input and output requirements, check with the inventory at hand and automatically raise purchase orders and also prepare different types of statements for planning and control purposes. Given a schedule of output requirements, the computer can work out the requirement of raw material and other bought out items and can plan the procurement and production of these so that there is no hold up of production due to non-availability of material.

Integrated Computer-Aided Manufacturing

These computer packages tie up the previous systems with mechanical systems that control machinery and material handling equipment. These packages do not carry out manufacturing of parts alone but also process planning, costing, tool design, production planning, material ordering etc. The rate of development in this area is extremely rapid and is also accelerating. Computers are used for both planning as well as execution of the plans.

Manufacturing Resource Planning (MRP II)

If the computerised production and inventory control systems could be linked with other planning and accounting systems of the organisation, it would result in comprehensive computer packages on manufacturing resource planning. Such a system would integrate marketing, finance, personnel, payroll and other systems and can prepare statements on funds requirement, promotional need, capacity planning and so on.

Group Technology

Group technology has developed over the years to become a complete philosophy rather than a single technique. The common thread running through all these techniques is the attempt to find groups which can be used in organising the transformation process. The purpose of grouping is to overcome some of the disadvantages of intermittent flow processing as outlined in 5.4 above and the grouping can be of component parts, machines, equipment and people.

In general, component parts are grouped into families so that the processing required for members of a family is similar. The machines and equipment are also grouped into cells so that the volumes through a cell are higher and the variety smaller. Therefore, the principles used in continuous flow processing can be used for each of these groups.

The benefits expected from group technology are really fourfold:

i) reduced amounts of time and costs because the nature of operations and their sequence is similar for a family of component parts

ii) reduced material handling as the machines and equipment in a cell are physically close to each other

iii) shorter throughput times as the waiting period between operations is minimal

reduced in-process inventories, again because of minimal waiting between operations.

3.5 CONTINUOUS FLOW PROCESSES

As distinct from intermittent flow processes, all outputs are treated alike in this form of processing and the workflow is thus relatively continuous. The production process is therefore geared to produce one output, perhaps with some options added on. The variety is small and volumes are high thus making it worthwhile to focus the transformation process on the output. This would mean arranging the facilities in the sequence in which they are required for the output, using high speed special purpose machines, laying out the facilities to minimise the movement of materials and designing the production system so that there are no bottlenecks as well as no idle time for any of the resources.

Traditionally, services were considered to be too customised for this form of processing. However, we are now finding that by standardising the service and also by increasing the volume of output, it is possible to use continuous processes even for services. One can give the example of fast food joints or periodic servicing of automobiles towards these trends.

Characteristics of Continuous Processes

The continuous process form is characterised by relatively standardised outputs and consequently fixed inputs, fixed sequence of operations and also fixed processing time. As the variation from one output to another is very small, the transformation process is selected and designed to maximise the efficiency of the resources and in the process flexibility of operations is sacrificed.

High Volumes

If an organisation is planning to produce only a small variety of outputs and in high volumes, it will find the continuous processing form a very attractive proposition. Because of high volumes, one can choose those production facilities which are special purpose and perhaps custom-built so that the initial costs are high, but they can produce the output at a low variable cost. The higher the volumes the further these tradeoffs shift towards higher fixed costs and lower variable costs. This is because the variable costs are low and the high fixed costs are spread over a high volume of output thus making the continuous processing form the least cost processing form for high volumes.

Easier Planning and Control

As all outputs follow the same path from one operation to the next, there is no need to keep track of each output for planning and control purposes. In other words, all operations being standardised with standard operation times and no waiting between operations, if the time when processing starts for an output is known, all subsequent operations including the final completion of the output can be predicted quite closely.

This implies that there is virtually no in-process inventory since there is no waiting between operations. Also, as the transformation process is designed specially for this output the amount of movement between operations is minimal. Further, as volumes are high, special purpose fixed position material handling equipment like chutes, conveyors etc. which have low space requirements and operate at low variable costs can be used.

Linear Workflow

All the facilities are arranged in the sequence in which they are required for the production of outputs. The material therefore moves from one facility to another or from one location to another with no backtracking at all. That is why product organisations of this form are often called flow shops.

When the continuous form of processing is used for production of an output, we have, what is called a **product line**. In many product lines we can actually see the material moving on a conveyor and workers removing one unit from the conveyor for processing and putting it back on the conveyor at the end of the operation so that it goes to the next location for the next operation. It is, therefore, important that the work content at each of the locations be exactly equal so that no location has a bottleneck nor does a location have idle time. The rate of output will be governed by the slowest location (referred to as work station in the context of a production line). Sometimes, when there is a large variability in the operation times, a small in-process inventory is allowed to be built up to cushion out the effect of such variations.

When only assembly operations are performed on a line, such a line is called an assembly line. Assembly of many low variety product is carried out using assembly lines-for example automobiles, television sets, domestic electrical appliances etc.

Advantages of the Continuous Form

The continuous form of processing requires a great deal of effort while designing. But once implemented, it offers many simplicities in its operation.

Low Unit Cost

The main advantage offered by continuous process operations is the low per unit cost of production. As discussed earlier, this is achieved by selecting equipment which provides low variable costs of operation perhaps at high initial costs which are distributed over large production volumes. Further cost saving is possible due to bulk purchasing of materials, efficient facility utilisation, low in-process inventories and lower material handling costs.

Lower Operator Skills

The machines used in continuous processes are generally special purpose and so their operation is simpler, with few setups required. The operator skills required are therefore lower which improves the availability of workers with requisite skills and also gives rise to lower labour costs.

However, the special purpose machines are more complex in their design and functions and so are more difficult to maintain. Thus, higher maintenance skills are required and since the experience of working on any of these machines is limited, the time taken for diagnosis and repair is longer. Similarly, spare parts availability itself could be difficult for special purpose machines.

Simpler Managerial Control

As the workflow is streamlined in the continuous form, the planning and control of production is much simpler. With standardised operations and operation times, the predictability of operations is higher. This implies that the performance on meeting delivery dates is better.

In fact, while operating an interrupted processing system, if one of the outputs establishes a high growth in volume, it may be worthwhile exploring the possibility of setting up a production line for this output. Although the component parts are produced using interrupted processing, the final assembly is carried out on an assembly line for many products.

Disadvantages of the Continuous Form

Although the continuous form of processing offers a low cost alternative when volume of production is high and the variety low, there are some disadvantages in organising the production in this form.

Difficult to Adapt

As the whole production process is designed for a particular. output, any change in the output characteristics is difficult to obtain. Because of this, important changes in product design are often not made, which can affect the competitive strength of the organisation. Each production or assembly line is designed, for a particular rate of production. Sometimes, it is difficult even to change the rate of output. This causes serious difficulty when the demand for the output increases or decreases.

Possibilities of Stoppage of Line

If there is a breakdown at any work station or in the material handling equipment, the whole line may come to a standstill. In the absence of work-in-process, production at all work stations will suffer till the line can be started again.

Balancing the Line

The work content at each of the work stations should be exactly equal to avoid bottlenecks and idling of resources. However, if it is not possible to exactly equalise the work content, the output rate is governed by the slowest work station which implies that workers at all other work stations are less busy. This remains a sore point among the workers.

Low Worker Morale

A worker's task is highly repetitive in the continuous form *of* processing and for high output rate production lines the task may also be very insignificant and unchallenging. This dehumanising aspect of the workers' role causes boredom, monotony and very soon starts affecting the morale of workers. '

High Initial Cost

The special purpose machines and equipment used in continuous form of processing have very high initial cost. It is also costly to service and maintain. Also, such special purpose equipment is very susceptible to obsolescence and it is not easy to find a buyer for such equipment or to modify these for other uses.

New Technology for Continuous Flow Process

Recent developments in computer applications have had their effect on continuous flow operations as well. The attempt in all this is to increase the flexibility of production and assembly lines.

CNC/DNC

Machines and processes which have been automated using some form of electronic system are said to use numerical control or NC. In the early NC machines, instructions for machine control were coded on punched paper tapes to be read by tape readers. In CNC (Computer Numerical Control) machines, relatively simple programmes can be stored in the memory of the computer and so it is not necessary to read the control tape for every item manufactured. This is an advantage since the control tapes and the associated tape readers are among the most unreliable components of an NC machine.

In DNC (Direct Numerical Control) machines, programmes for a number of NC machines are stored in a single computer of larger capacity than the type used in CNC. Also, the integration of a number of machines and processes by one computer enables a set of machines to work as a manufacturing system, with parts scheduling and process monitoring. Automation by numerical control can be thought of as soft automation as this allows fast changeovers from one component part to another.

Robotics

According to the Robot Institute of America, "A robot is a reprogrammable multi-functional manipulator designed to move material, parts, tools or specialised devices through variable programmed motions for the performance of a variety of tasks." Robots have come in a big way in the task of moving, transferring and manipulating materials in between operations as well as during some specialised operations. An industrial Robot has three principal components:

i) One or more arms, usually situated in a fixed base, that can move in several directions

ii) A manipulator, being the "hand" that holds the tool or the part to be worked

iii) A controller that gives detailed movement instructions.

Robotics is helping continuous flow processes to changeover from one output to another since the material handling equipment, which was earlier designed as part of a production or assembly line, can now be independently programmed.

CAD/CAM/CAE

This trilogy of terms stands for computer aided design (CAD), computer aided manufacturing (CAM) and computer aided engineering (CAE). In these systems, the computer aids in the design process by providing different images of the designed product from different views-the computer screen acting as the designer's drawing board. The CAM ties the NC machines with the material handling equipment so the manufacturing operations are working together. In CAE, the computer is used to aid in analysing engineering problems, particularly structured analysis where the structure has previously been designed using CAD. In its widest sense, these imply the automation using computer control of all activities necessary to take a product from concept to its completed manufacture.

Flexible Manufacturing

Current usage of the term flexible manufacturing relates to automated manufacture. Traditionally, automation in manufacturing has been possible only for high volume low variety products where the production process adopted had been of the continuous flow process form. Such process had suffered from inflexibility-not only in terms of output characteristics but also of output rate. In flexible manufacturing an attempt is made to introduce flexibility not only in terms of component design but also operation sequence, batch sizes and overall production capacity. Flexible manufacturing tries to combine the advantages of conventional automation with the strategic advantages attached to intermittent processing viz., increased variety, improved response to customer orders, updated product designs etc.

3.6 PROCESSING INDUSTRIES

The processing industries e.g., fertiliser,' petrochemicals, petroleum, milk, drugs, etc. also use continuous processing. However, they deserve a special mention as they differ from organisations producing either discrete products or services. In general, the operations in these organisations are highly automated with very sophisticated controls, often electronic or computerised. The labour requirements are generally low and the, role of the production workers is limited to monitoring and taking some corrective action if necessary. However, maintenance of equipment is very critical and the skills required in maintenance are of high order.

A Single Input

In processing industries, there is usually a single principal input material which is processed into one or more different products. In discrete manufacturing, on the other hand, there are many different input materials which are processed and assembled to form the product.

Analytic and Synthetic Processes

In an analytic process, a single, input is processed into many separate outputs. A typical example would be a petroleum refinery, where the single input, viz. petroleum is processed into petrol, diesel, naphtha, furnace oil and a host of other intermediates. In a synthetic process, on the other hand, many different inputs are synthesised into one output. Processing industries generally use analytic processes whereas continuous flow processing in disc etc manufacturing generally use synthetic processes.

Continuous Processing

In spite of the differences mentioned above, there is a basic similarity in the concept as well as the approach followed in both flow shops and the processing industries-- only the variety in outputs is nil so far as processing industries are concerned. Because of ill's, automation could be carried out to its physical limits and the process is designed for a specific mix of outputs. The result is that initial set -up of equipment and procedures is even more complex and critical than for continuous flow processing.

3.7 SELECTION OF THE PROCESS

In this section we would address ourselves to the issue of selecting the appropriate process form or mix of forms for an organisation to produce its output. The details involved in the actual designing and laying out of the transformation processes, the laying out of the workplaces, the designing of the planning and control procedures; the assurance of quality, etc. is the subject matter of the complete course and would be taken up later in other units.

Combination of Process Forms

The four forms of processing that we have referred to earlier are really four simplified extremes of what is likely to be observed in practice. We will find very few organisations using only one of these processing forms in its pure sense. In fact by alluding to concepts like group technology and flexible manufacturing we have referred to systems which attempt to combine the advantages of two or more of these, pure forms.

Most organisations combine two or more of these process forms to produce different components and the final product. In many industries including automobiles, domestic electrical appliances etc. the components are made using the intermittent form of processing whereas the final assembly is based on continuous flow processing.

Production of Services

Like products, services could also be produced using different process forms. Although the intermittent processing form has been the typical form used for services, services as those provided by a lawyer are more like project processes. Again, by standardising the outputs and consequently increasing the volume of standard outputs, many services are now produced using the continuous flow process form. We have already given the example of fast food service in this context. Another example comes from the Soviet Union where a flowline has been used for routine eye surgery whereby patients are literally passed along a line from one surgeon to another, each of whom performs a small part of the total operation. We are, therefore, slowly coming to realise that services can be mass produced.

Product/Process Life-cycles

In Units 1 and 4 we have referred to the life-cycle which a typical output undergoes-from its introduction through growth, maturity and decline phases.

. There is a similar life-cycle for the process used to produce the output. Figure I can be interpreted to show that the product and the process life cycles are related.

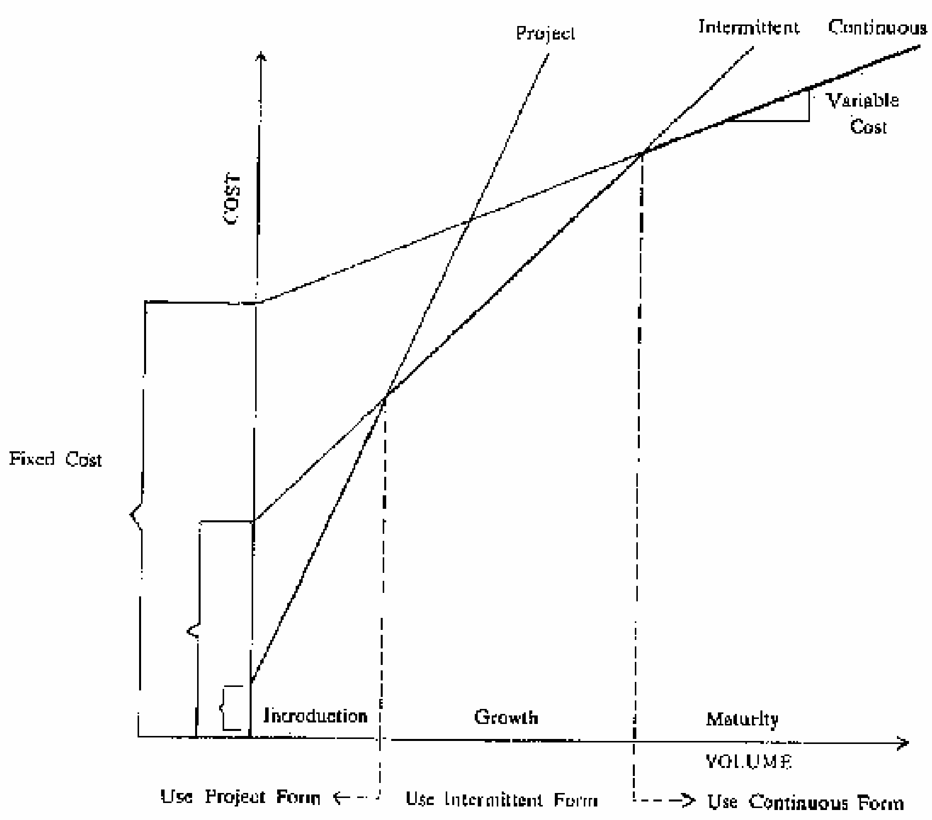
When an output is just introduced, it is made in small volumes in an inefficient, uncoordinated manner which might start using the project form. However, very soon it is produced in small batches using the intermittent processing form. As the output goes through the growth phase, more and more sub-processes are designed using the continuous flow processing form. Finally, in the maturity phase, the product competes mostly on price. The volumes are high and highly cost efficient methods are required to produce the product at a low cost. The continuous flow processing form is then the most suitable form of process.

Break-even Analysis For Process Forms

The progress along the process life-cycle is shown below in Figure III using break-even analysis for each of the process forms. At the introduction stage, the product is first produced with little or no commitment of equipment and facilities using mostly labour intensive methods. The process form used is the project form and most of the cost is variable cost including the cost of labour.

As the product passes on the growth phase, general purpose machines and equipment are organised into the intermittent form to produce the output in a flexible manner. Finally, when the continuous flow processing form is used towards the maturity phase of the product life-cycle, the fixed costs of operation are very high and the variable cost per unit of output is quite low. Figure III also shows the least cost process at any stage of the life-cycle (heavy line) and it can be easily seen` that as volumes rise a different form of process might become the least cost alternative.

Figure III: Break-even analysis of process form selection with phases of life-cycle.



Maintaining the Focus

The point to note is that the process form adopted should evolve as the market and the output evolve. If a company feels that its competitive strength lies in having a flexible production system-which can respond very fast to specific customer needs, then as the outputs move into another phase of their life-cycle in which a different process form is preferable, it drops the output or licences it to someone else and switches to another output more appropriate to its, competitive strengths.

Each factory or office should have a clearly defined focus in its operations and the process form adopted is one of the key elements that creates the focus. It is not possible to have a production system which can satisfy all sorts of demands Made on it--e.g., fast response to changes in output design, low cost of production, high capacity utilisation of resources, and so on.

3.8 SUMMARY

In this unit we have looked at the various process forms that can be used to effect transformation of inputs into outputs. Having established the strategic nature of process selection decisions, we explored the various considerations which affect the process selection. The major consideration in choosing an appropriate process form is the output characteristics in terms of its volume and variety. A related consideration is whether the output is produced-to-stock or produced-to-order.

When the output is produced in very low volumes and the output variety is large, the project form of transformation is often the most appropriate. Project processes have short life-cycles and need a high level of coordination so that in spite of strict precedence relationships between activities, the project is not delayed beyond its scheduled date of completion.

For low volume high variety output, the intermittent flow processing form offers the advantage of flexibility at reasonable cost, whereas for high volume low variety outputs, the continuous flow processing form is often used. We have looked at the characteristics of these process forms in great detail and also discussed the advantages and disadvantages of each of these. We have also mentioned some of the new technologies for each of these process forms.

When the output has no variety, and if it is a commodity, the processing form offers great cost savings by using highly automated transformation processes where the role of production workers is only to monitor the processes and take corrective action, if needed.

We have noted that most organisations adopt a combination of different process forms. Just like products, even services can be mass produced if the variety can be reduced giving rise to high volumes. Interestingly, different process forms might become the most appropriate ones depending on the phase of the product life-cycle the output is in and so we have some kind of a process life-cycle as well. However,, it is important to have a clear focus in the operations of a factory or an office.

3.9 KEY WORDS

An adaptive process: A process which has to continually adapt to many external factors.

Produce-stock: A production policy which allows products to be produced and stocked in our warehouse and sold as and when demand occurs.

Produce-to-order: A production policy which allows outputs to be produced only on receipt of an order from the customer.

Project form of processing: Used to produce an output which is one of a kind.

Reaction times: Time required for an organisation or a system to react to a change either internal or external.

Matrix organisation: A form of organisation structure in which a dual system of grouping is adopted, e.g., a person is assigned to a project which he or she retains membership of the functional organisation,

Intermittent form of processing: When the. output variety is large, the production facilities are organised specialisation-wise, thus making the material flow non-uniform, zig-zag and intermittent.

Flexibility refers to the ease with which a productive facility can be used to produce different outputs.

In-process inventory: The stock of semi-finished products usually required to cushion the effect of unequal production rates and to balance the high set up cost for some operations.

Group technology: Attempts to find groups of component parts, machine equipment and people which can be exploited while organising the team formation process.

Line balancing: Implies that each work station in a production or an assembly line has an equal work content so that no work station has an idle time, nor does it have bottlenecks:

NC or numerical control refers to the use of some form of electronic system for automating machines process.

Flexible manufacturing is the approach towards making automated t manufacture. flexible both in terms of output characteristics and output rate.

Analytic process: In an analytic process, a single input is processed into many separate outputs.

Synthetic process: In a synthetic process, many different inputs are synthesised into one output.

3.10 SELF-ASSESSMENT EXERCISES

1 The equipment used in intermittent flow shops is less specialised than that used in continuous flow shops. What about the labour?

2 Can flexibility or economy be obtained only at the cost of each other?

3 Why do you think is managing a high-volume continuous operation easier than managing a high-variety intermittent operation?

4 Please explain why the in-process inventory is likely to be higher for an intermittent operation than for a continuous flow operation?

5 Hospitals are commonly physically laid out as continuous flow systems. (True/False).

6 The continuous form of processing is the most economical when the system requires flexibility.(True/False).

7 Special purpose equipment are more likely to be affected by obsolescence than general purpose equipment. (True/False)

3.11 FURTHER READINGS

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