PLANT LAYOUT

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Plant Layout

Topics to study:

- Principles of Plant layout and Types, factors affecting layout, methods,
- Factors governing flow pattern, travel chart, analytical tools of plant layout,
- Layout of manufacturing shop, repair shop and services sectors.

PLANT LAYOUT

- **Plant layout:**

- An optimum arrangement of industrial facilities, including personnel, equipments, storage space, material handling equipments and all other supporting services, in an existing or proposed plants.

- "A technique of locating machines, processes and plant services within the factory in order to secure the greatest possible output of high quality at the lowest possible total cost of production."

- All facilities like equipment, raw-materials, machinery, tools, fixtures, finished goods, in process inventories, workers, material handling equipments etc. are given a proper place in the plant layout.

Objectives of a good plant layout

Objectives of a good plant layout

1. Integrate the production centres**.** A good layout integrates the production centres (men, materials and machines) into a logical, balanced and effective production unit.

2. It permits the arrangement of the equipment to provide greater utilization.

3. A good layout will minimize the production delays and reduce congestion, by allowing smooth and continuous flow of raw-material and work in process.

4. It helps to increase the output by shortening the manufacturing time.

5. Reduce Material Handling. The equipments may be a manner to minimize material handling and n.

Objectives of a good plant layout

6. Effective Utilization of available Space. Moreover, a good layout utilizes space, both vertical and horizontal in the best possible manner.

7. Worker Convenience and Job Satisfaction. Reducing excessive noise and safety convenient working temperature, ventilation, light, Removal of moisture and dirt, Safety.

8. Flexibility. A good layout should be adaptable to possible changes in the plant's production programme; either changes in product design or changes in the required output.

9. Removal of bottlenecks. A good plant layout eliminates bottlenecks through balancing of plant capacities.

Objectives of a good plant layout

10. Quick disposal of work

    Good layout allows quick disposal of work and minimum waste of time in production.

11. Avoids industrial accidents

12. Eliminates physical efforts required of operative workers.

13. Maintenance of decency and orderliness inside the plant area.

Importance of Plant Layout

- It determines the arrangement of facilities and services in the plant. It outlines the relationship between production centres and service departments.
- It outlines the nature of flow in the plant and affects the distance travelled by materials and personnel, hence it is concerned with the time, effort and costs spent on transportation.
- It determines the type of handling systems their integration in the overall production program, and the cost of their installation.
- It specifies the location, accessibility, and size of stores, and also the space and location of temporary storage for work in process.
- Machine utilization is partly determined by layout.

Importance Of Plant Layout

- Production planning and control systems may he greatly affected, particularly the complexity of routing, machine loading, expediting and the paper work involved in control mechanism.
- The amount of supervision required and the degree of specialization necessary in supervision is sometimes dependent on layout.
- It greatly affects the amount of work in process and work awaiting further processing.
- Operator's span of activities, working time, fatigue, and efficiency may be affected by layout considerations.

SITUATIONS IN WHICH LAYOUT PROBLEM MAY ARISE

- When starting a new plant
- Changes in the product design
- Necessity of introducing a new product
- Necessity of changes in the volume of production
- Poor working conditions
- Frequent accidents
- Changes in location of the industry.

FACTORS INFLUENCING PLANT LAYOUT

1. **Management Policy:**
   Nature and quality of products, size of the plant, integration of production process, plans for expansion, amount of inventory in stock, employee facilities etc.

2. **Manufacturing Process:**
   The type of manufacturing process, e.g. synthetic/analytical, continuous/ intermittent and repetitive/non-repetitive, will govern the type of plant layout.

3. **Nature of Product:**
   Small and light products can be moved easily to the machines whereas for heavy and bulky products the machines may have to be moved. Large and heavy equipment requires assembly bays.

4. **Volume of Production:**
   The plant layout and material handling equipment in the large scale organisation will be different from the same in the small scale manufacturing industry.

FACTORS INFLUENCING PLANT LAYOUT

5. **Type of Equipment:** The use of single purpose and multi-purpose machines substantially affects the plant layout. Similarly, noisy and vibrating machines require special attention in the plant layout decision.

6. **Type of building:** The plant layout in a single storey building will be different from that in a multi-story building. The covered area, the number of stories, elevators and stairs, parking and storage area all affect the layout.

7. **Availability of total floor area:** The allocation of space for machines, work-benches, sub-store, aisles, etc is made on the basis of the available floor area. Use of overhead space is made in case of shortage of space.

FACTORS INFLUENCING PLANT LAYOUT

8. Arrangement of material handling equipment:

It is necessary to provide adequate aisles for free movement of material handling equipment such as hand truck, fork truck etc.

9. Service facilities: The layout of factory must include proper service facilities required for the comfort and welfare of workers. These include canteen, lockers, drinking water, first aid etc.

10. Possibility of future expansion: Plant layout is made in the light of future requirements and installations of additional facilities.

PRINCIPLES OF PLANT LAYOUT

- According to Muther, there are six basic principles of best layout:

1. Principle of overall Integration: According to this principle, the best layout is one which integrates the men, materials, machinery, supporting activities and any other such factors that results in the best compromise.

2. Principle of minimum movement: According to this principle, the number of movements of workers and materials and the distance moved should be minimized. The material should he transported in bulk rather than in small amounts.

3. Principle of smooth and continuous flow: It states that, bottlenecks, congestion points and backtracking [illegible]d by proper line balancing techn[illegible]

PRINCIPLES OF PLANT LAYOUT

4. Principle of cubic space: Besides using the floor space of a room, if the ceiling height is also utilized, more materials can be accommodated in the same space.

Boxes or hags containing raw- materials or goods can be stacked one above the other to store more items in the same work space.

Overhead material handling equipments save a lot of floor space which can be utilized for productive purposes.

5. Principle of satisfaction and safety: Working places should be safe, well-ventilated and free from dust, noise, fumes, odours and other hazardous conditions helps to increase the efficiency of the workers and improve their morale.

6. Principle of flexibility: It means that the best layout is one which can be adopted and re-arranged at a minimum cost with least inconvenience.

Basic Information Required for Plant Layout Planning

- Dimensional plan of the space laid out.
- Description of the operations, their sequence and standard times in production process.
- Volume of work to be taken from the space at present and in future.
- Nature of machines and equipment needed to perform the operations.
- Type and quantity of labour required.
- Amount of material, buffer stock required at each work station.
- Size of finished and semi-finished product inventory.
- Kind of communications and fire-exits necessary for plant.
- Special requirement if any to fulfill the local bye-laws.
- Special geographical and inspection requirements.

Basic Information Required for Plant Layout Planning

- The layout is mainly planned by trial and error i.e. laying out, modifying and relaying out.
- Visual aids play an important role in layout planning. Some form of scale representation is normally used viz, scale drawing, templates, models, string diagrams etc.

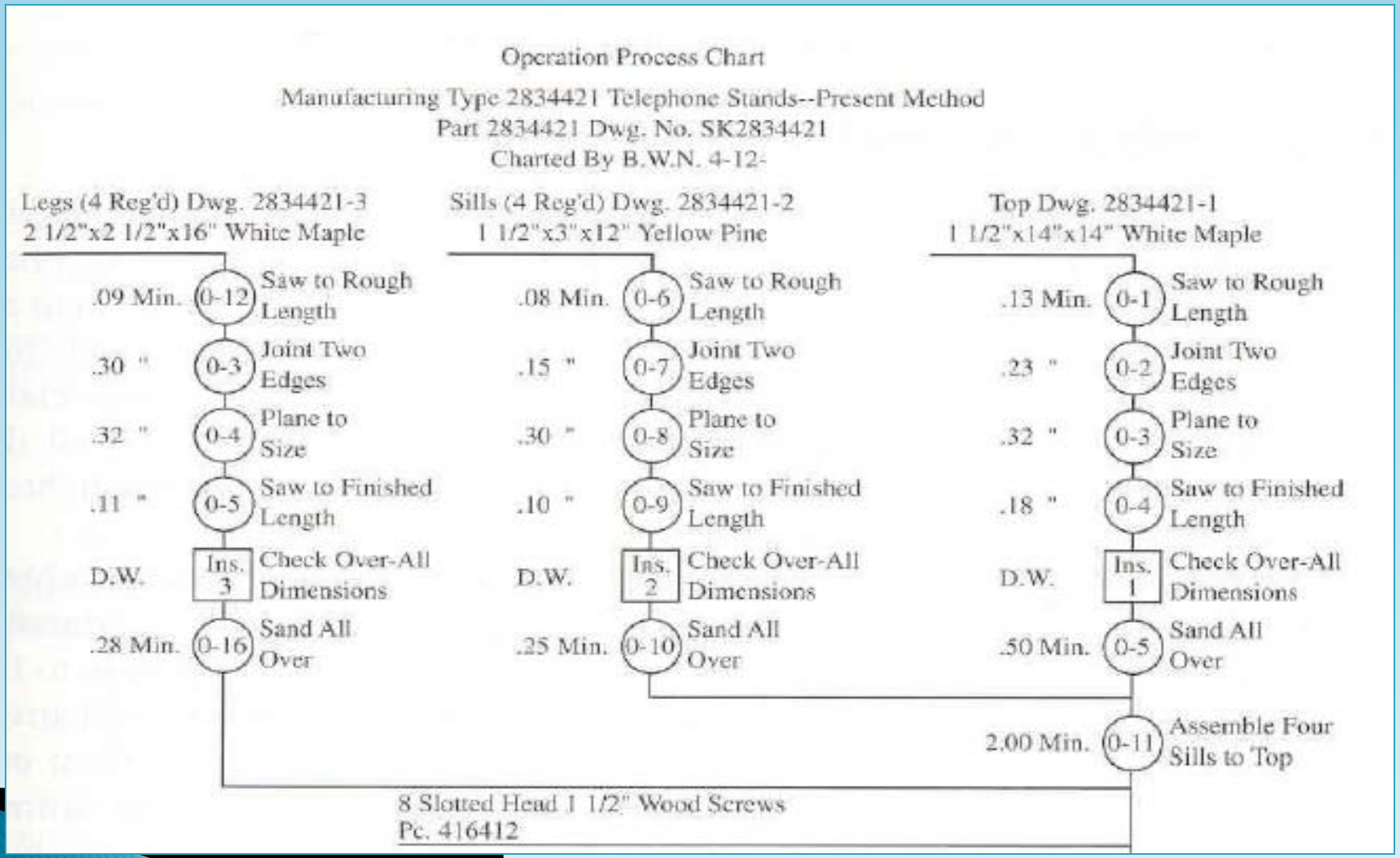
Plant layout Tools and Techniques

- Operation process charts
- Flow process charts
- Flow diagrams
- Machine data cards
- Templates
- Three dimensional models.

Operation Process Chart

- The operation process chart subdivides the manufacturing process into its separate operations and inspections.
- It indicates the points at which materials are introduced into the process and the sequence of all operations and inspections except those involved in material handling.
- The operation process chart is used when a new plant is to be laid out. It represents the basic activities to be provided for producing a product.
- It presents the overall visualization of the process and serves as a basis for studying possibilities for the improvement of operations by elimination, arrangement or simplification.

Operation Process Chart Example



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Flow Process Chart

- This chart is a graphic representation of all production activities occurring on the floor of the plant.
- It is an elaboration of the operation process chart to include transportation, storage and delay.
- The data for constructing the flow process chart are collected by tracing the actual flow of work occurring in the plant, from the receipt of raw-material to the completion of the product. These data include the distance travelled and the time required for the operation.
- It provides the complete information for the analysis and improvement of plant operations as a whole. As a result of analysis operations may be eliminated, combined, or rearranged.
- An improved flow process chart provides a basis for revising an existing plant layout. The chart is also used to check and verify posed floor plan for a new layout.

Flow Process Chart (Material)

Flow Process Chart Page 1 of 1

Location: Dorben Ad Agency		**Summary**			
Activity: Preparing Direct Mail Ads		**Event**	**Present**	**Proposed**	**Savings**
Date: 1-26-98		Operation	4		
Operator: J.S.	Analyst: A.F.	Transport	4		
Circle appropriate Method and Type:		Delay	4		
Method: (*Present*) *Proposed*		Inspection	0		
Type: *Worker* (*Material*) *Machine*		Storage	2		
Remarks:		Time (min)			
		Distance (ft)	340		
		Cost			

Event Description	Symbol	Time (In Minutes)	Distance (In Feet)	Method Recommendation
stock room	○ ⇨ D □ ▽			
to collating room	○ ⇨ D □ ▽		100	
collating rack by type	○ ⇨ D □ ▽			
collate 4 sheets	○ ⇨ D □ ▽			
stack	○ ⇨ D □ ▽			
to folding room	○ ⇨ D □ ▽		20	
jog, fold, crease	○ ⇨ D □ ▽			
stack	○ ⇨ D □ ▽			
to angle stapler	○ ⇨ D □ ▽		20	
staple	○ ⇨ D □ ▽			
stack	○ ⇨ D □ ▽			
to mail room	○ ⇨ D □ ▽		200	
addressing	○ ⇨ D □ ▽			
mailbag	○ ⇨ D □ ▽			

Flow process chart (worker)

Flow Process Chart

Page 1 of 1

Location: Dorben Co.	
Activity: Field Inspection of LUX	
Date: 4-17-97	
Operator: T.Smith / Analyst: R. Ruhf	
Circle appropriate Method and Type:	
Method: (Present) Proposed	
Type: (Worker) Material Machine	
Remarks:	

Summary

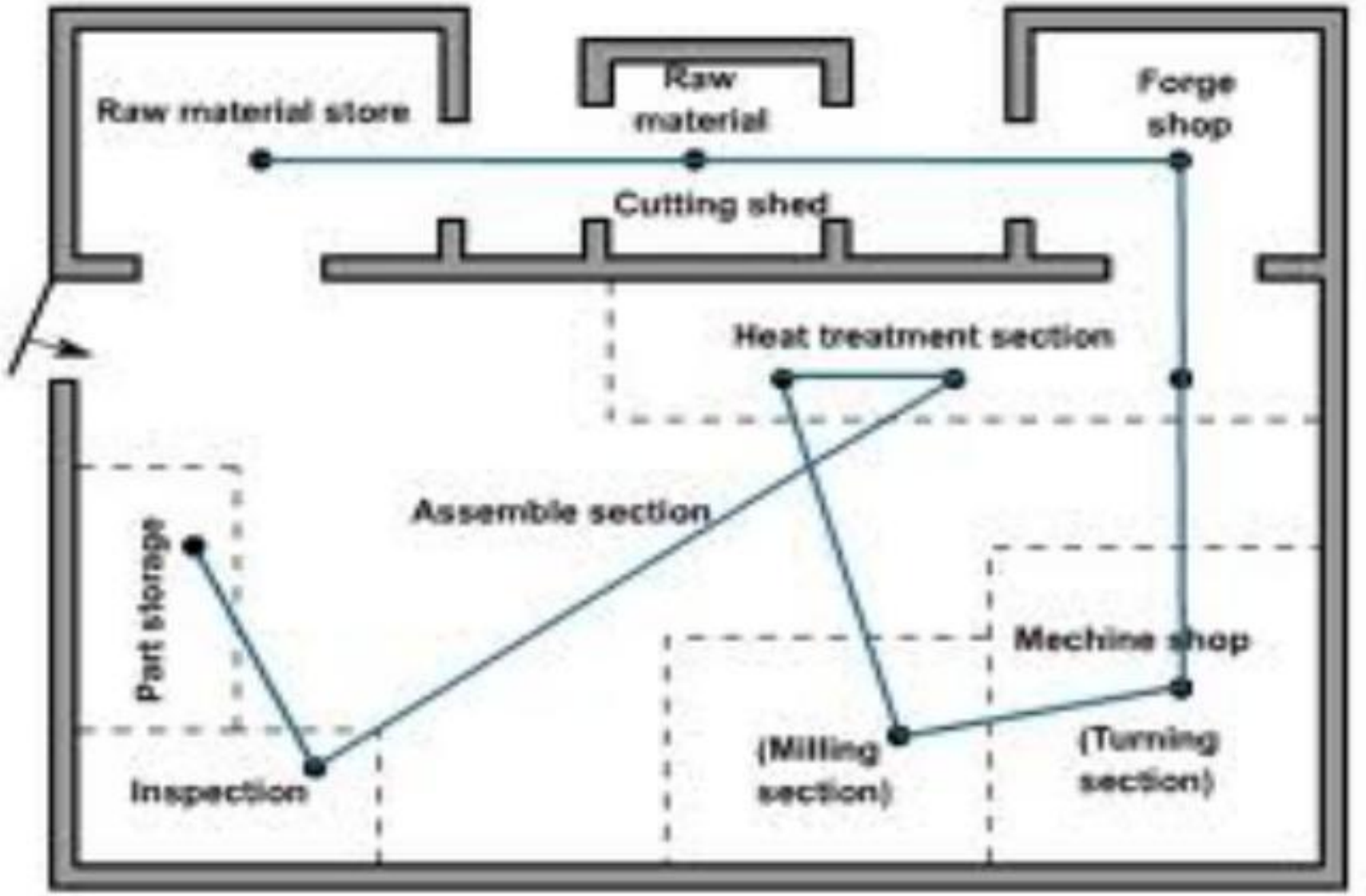
Event	Present	Proposed	Savings
Operation	7		
Transport	6		
Delay	2		
Inspection	6		
Storage	0		
Time (min)	32.60		
Distance (ft)	375		
Cost			

Event Description	Symbol	Time (In Minutes)	Distance (In Feet)	Method Recommendation
Leave vehicle, walk to front door, ring bell.		1.00	75	Call home in advance to reduce waiting delays.
Wait, enter home.				
Walk to field reservoir.		.25	25	
Disconnect field reservoir from unit.		.35		
Inspect for dents, cracks in shroud, cracked glass or missing hardware.		1.25		This can be done while walking back to vehicle.
Clean unit with approved cleaner and disinfectant.		2.25		This can be done more effectively at vehicle.
Return to vehicle with empty tank.		1.00	75	
Unlock vehicle, place empty tank in fixture and connect hardware.		1.75		
Open valve; begin fill.		.25		
Wait for tank to fill.		12.00		Clean unit while being filled.
Check humidifier for proper function.		.5		Eliminate. No need to do this twice.
Check pressure (indicator).		.2		
Check reservoir contents (indicator).		.2		
Return to patient with filled tank.		1.10	100	
Hook up filled tank.		1.00		
Check humidifier for proper function.		.75		

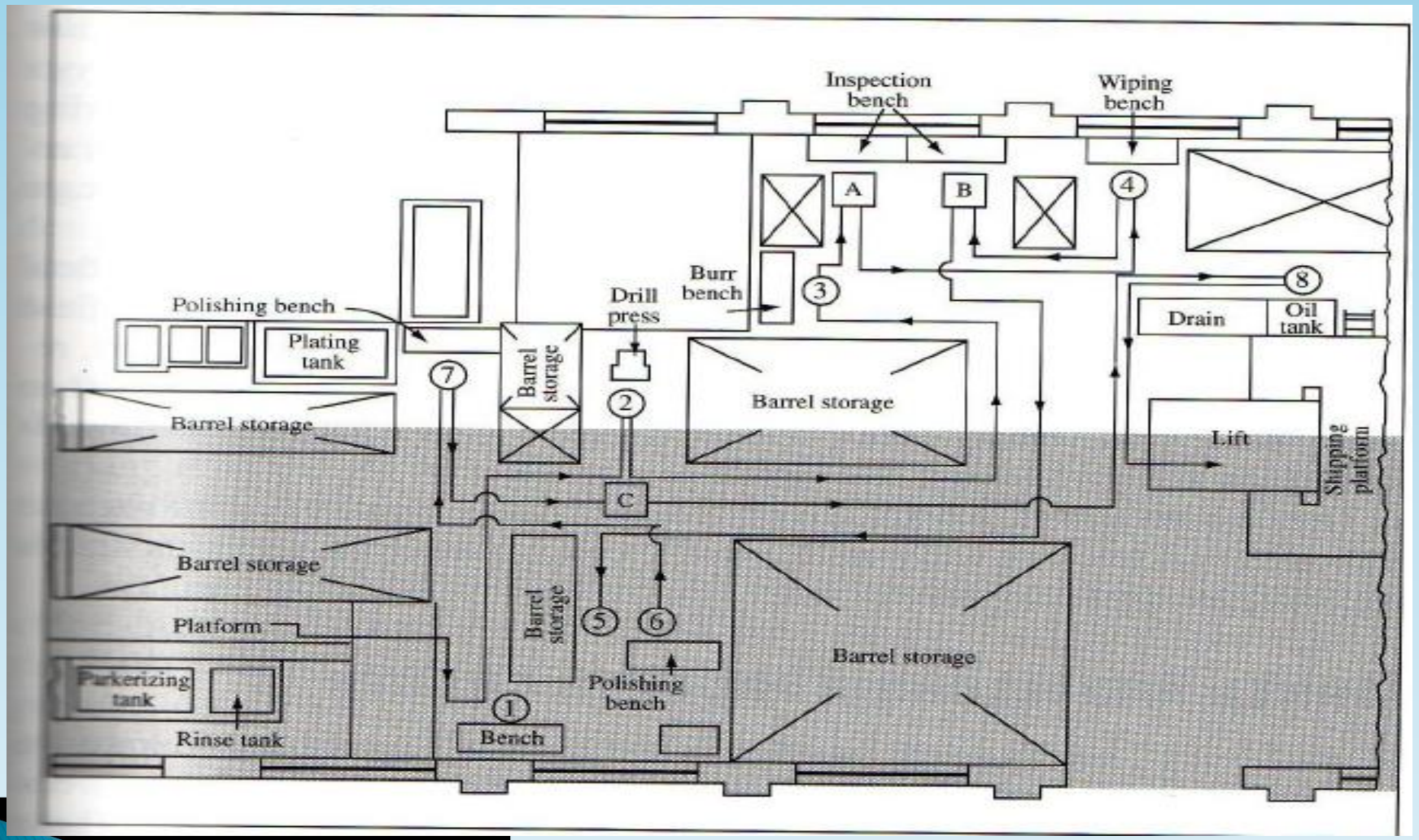
Flow Diagrams

- The flow diagram is used to supplement the flow process chart. It is a plan of the work area **drawn to scale.**
- It shows the relative position of productive machinery, storage area, gangways etc. and the path followed by men or materials is marked on the flow diagram.
- All routes followed by different items are shown by joining the symbols with straight lines.
- A study of the flow diagrams, along with the flow process chart will trace out the undesirable characteristics of the layout which are responsible for increased transportation and delays.
- It also shows the nature of back tracking involved which could be avoided by suitable changes in the layout.

Flow Diagram for Manufacture of Bi-cycle Pedal Axle

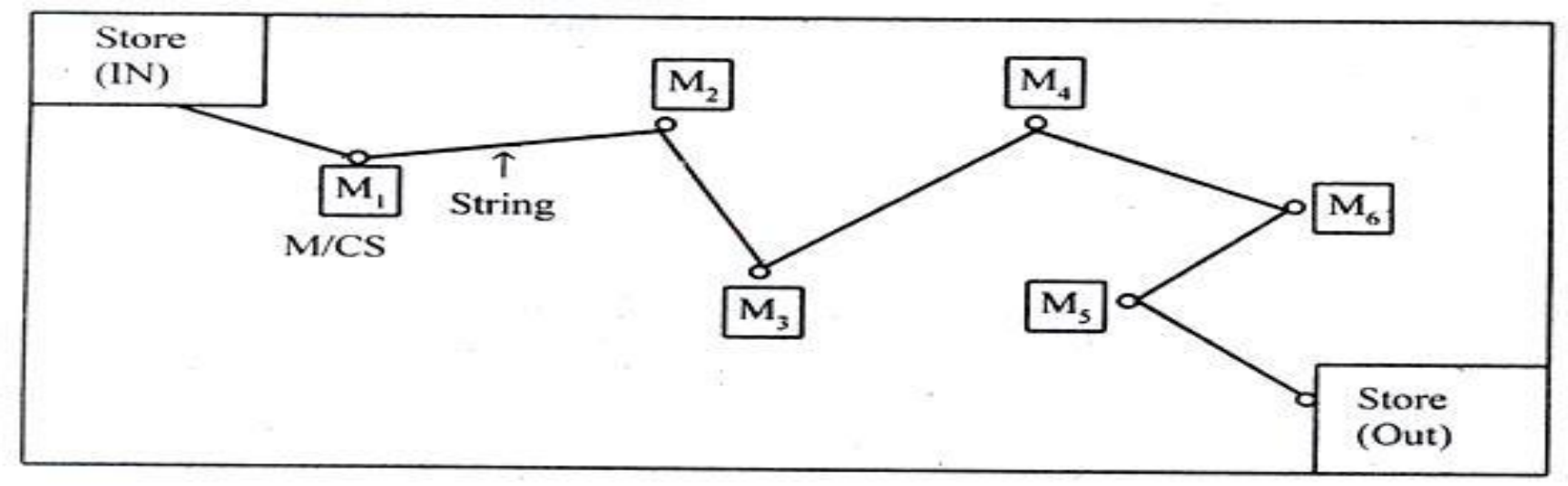


Flow diagram of a rifle plant

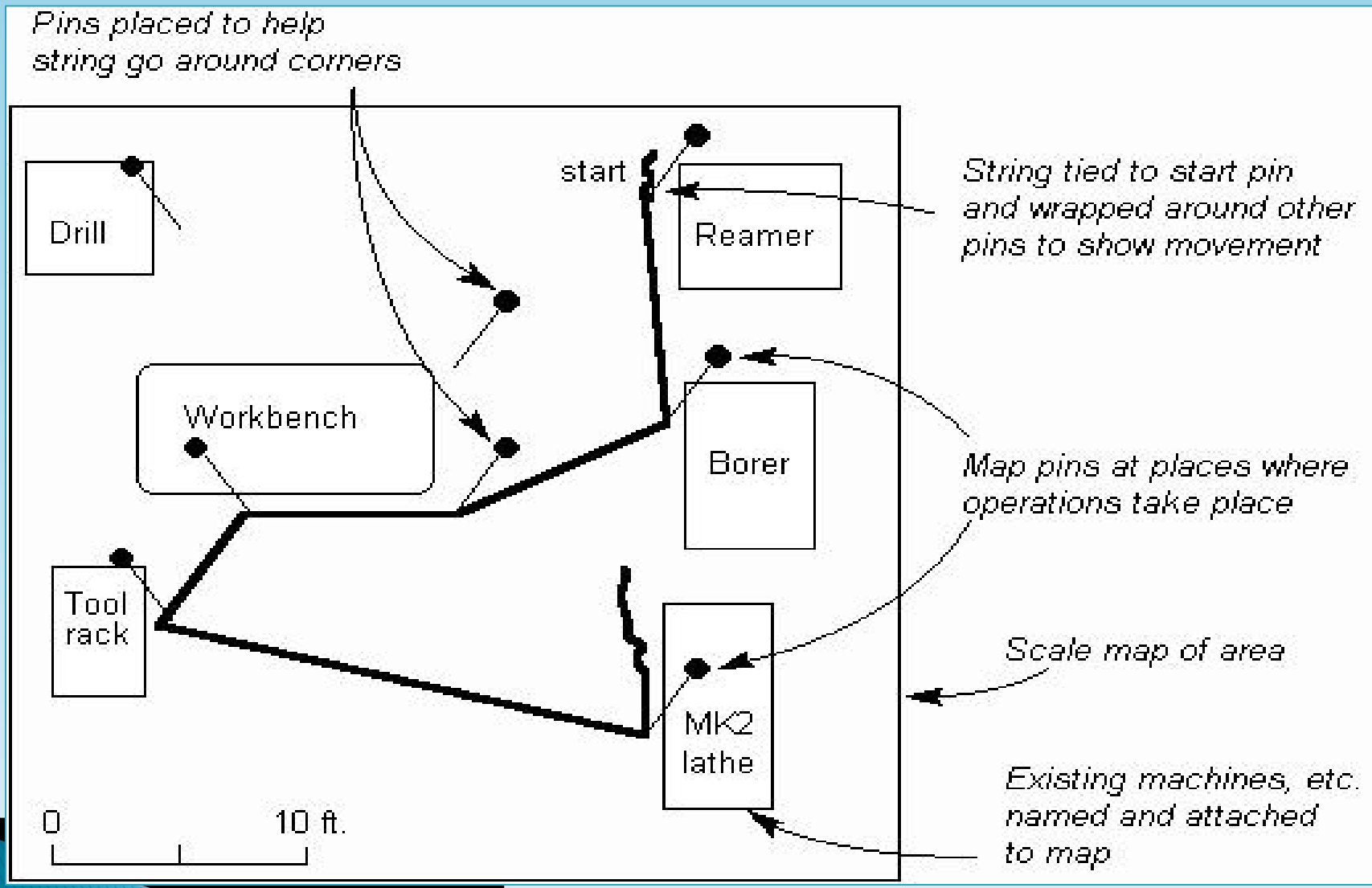


String Diagrams

- The string diagram is a scale plan or model on which a thread is used, to trace and measure the path of workers, material or equipment during a specified sequence of events.



String Diagram



Machine Data Cards

- These cards are prepared for each machine showing its capacity, space and other requirements, handling needs and the corresponding dimensions.
- This is an effective tool to provide necessary information for placement or layout of **equipments**.

Templates

- The area required by machine/equipment, benches, racks, material handling equipment etc. may be cut to scale from a sheet of cardboard, plywood or plastic.
- Different coloured templates may be used to indicate different items.
- These templates can be placed and attached on the work area drawn to scale.
- These templates are flexible in use and can be moved on the scaled plan of the work area in order to evaluate various feasible positions for different facilities.

Templates

- While positioning these templates it should be ensured that the gang ways are wide enough to allow the free movement of material handling equipments and goods in process.
- A template is generally prepared to a scale of I : 50 or I : 100.
- A two-dimensional template gives machine outline and its details whereas a block template shows the boundary of the maximum projected area of the machine.

Three Dimensional Models

Three dimensional models are convenient to study the movements on several floors of a multi-storey building.

They are particularly useful while analyzing the material handling problems in chemical industries; where the material moves upwards and downwards.

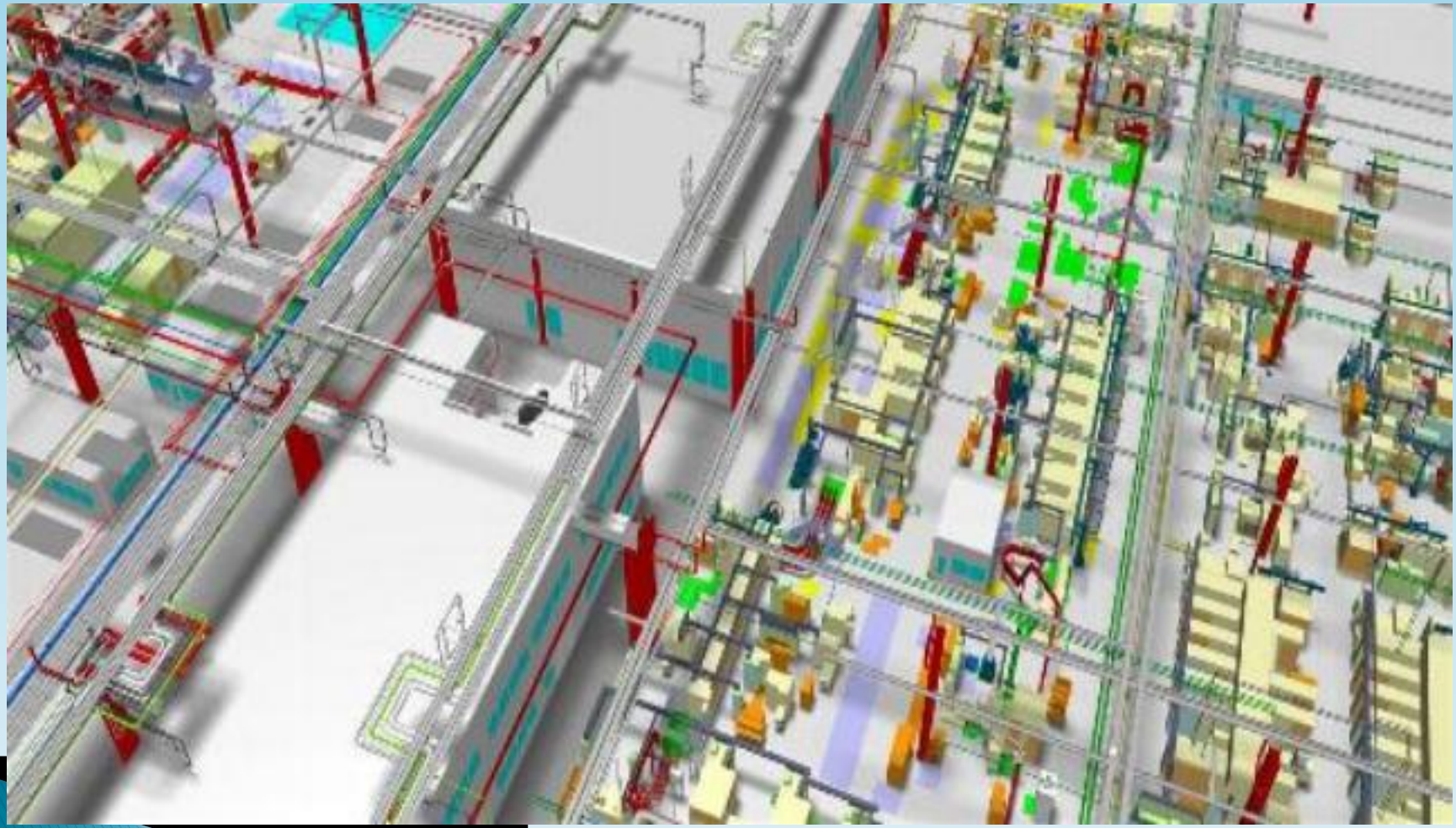
Advantages:

- It provides a visual aid in understanding the layout by non-technical personnel.
- Layout can be easily explained to management.
- It is easy to shift the models for study of the alternative operational arrangements.
- It facilitates the study and checking of overhead structures.
- They convey more or less a real situation.

Disadvantages:

- They are costly, difficult to make.
- They require more storage area.
- It is difficult to take them to shop floor for reference purpose.

Three Dimensional Model



3-D MODEL

TYPES OF PLANT LAYOUT

- 1. Process layout or functional layout .
- 2. Product layout or Line layout
- 3. Mixed layout.
- 4. Static layout

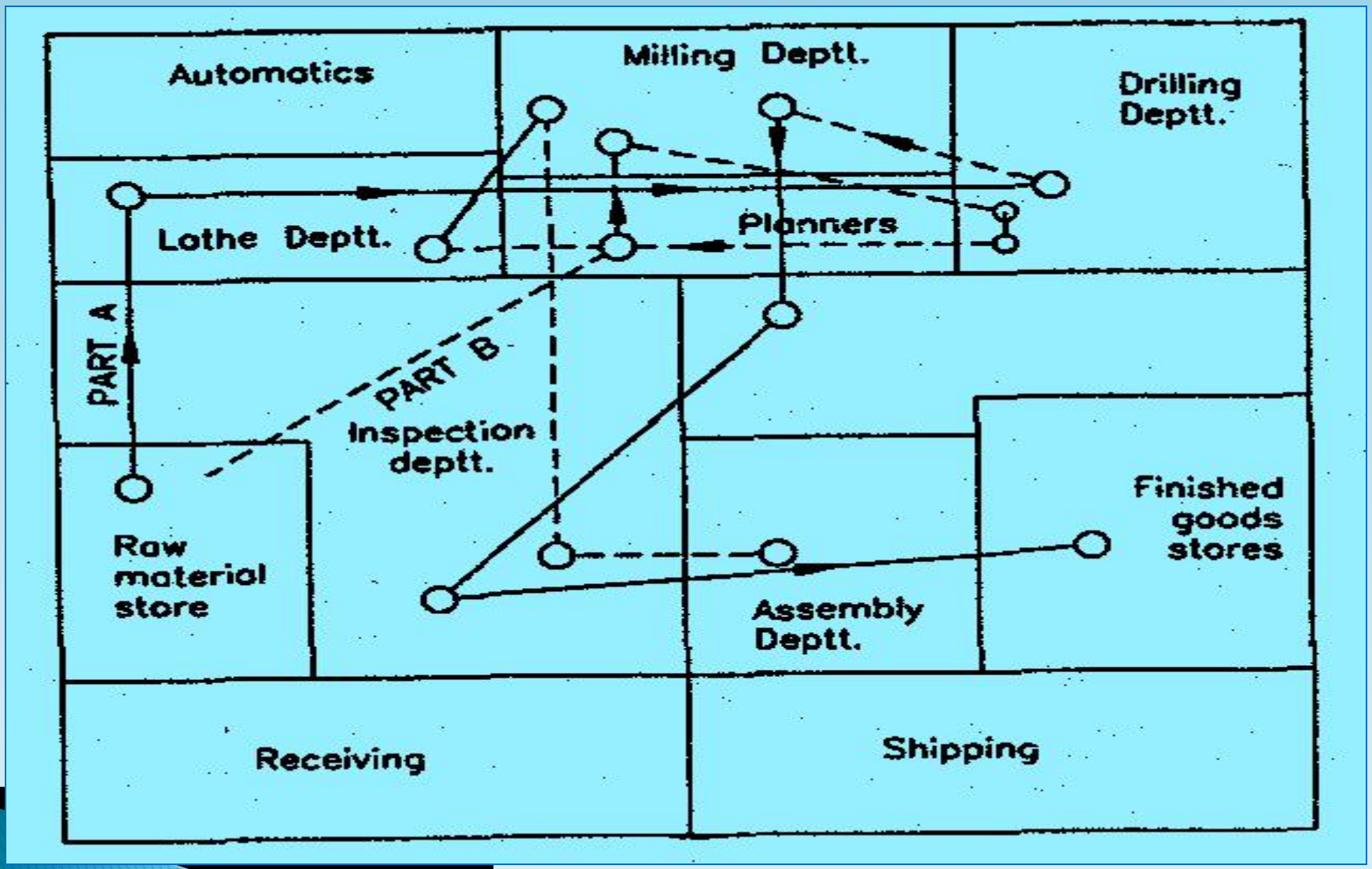
1. Process Layout. : Also called functional or job lot layout.

- In a process layout all similar machines are grouped together. As an example, all lathes grouped together in turning section. milling machines grouped together in milling section etc. So there are different sections or shops such as turning section, milling section, drilling section, welding section, assembly line etc.

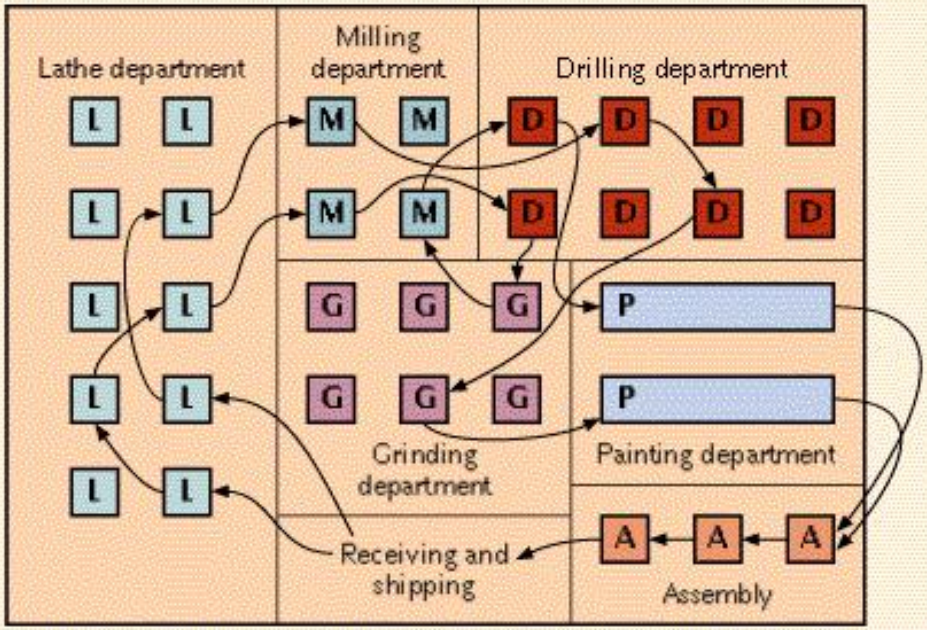
Process layout

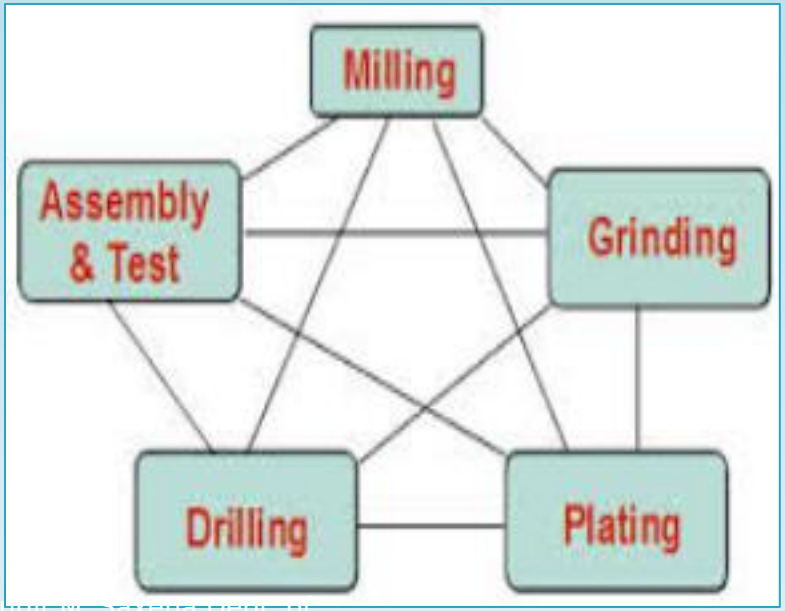
- Process layout is used in job and batch production, and non-repetitive type of work. It is employed when part and product designs are not stable or the volume of production is small.
- The primary requirement in process layout is flexibility, routing flexibility, part design flexibility, volume flexibility.
- Equipment utilization is very good and total investment in equipment is low.

Process layout



Process layout





Product or Line Layout

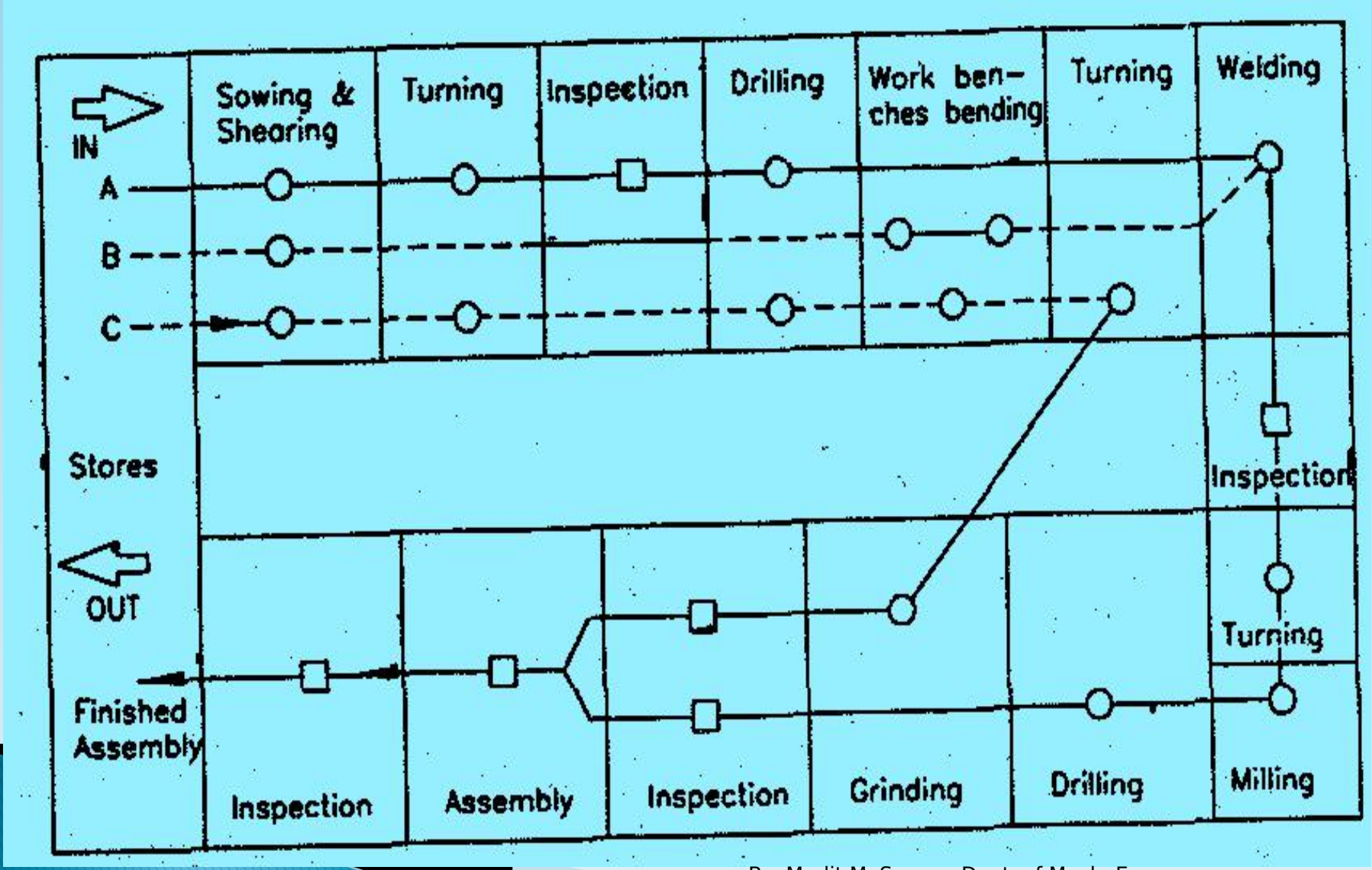
- **In this type the machines and auxiliary services are arranged in line according to the sequence of operations to be performed on the work.**
- The raw-material enters in the line at one end, the operations are carried out in succession, in a smooth flow and the finished product is delivered at the other end of the line.
- In this type of layout, there will be a separate production line for each type of product. Each line may have same machines though they may be arranged differently, or the machines for each line may be different.
- Product layout is suitable for continuous production.

Product or Line Layout

The conditions for line layout are:

- Adequate volume of production for reasonable equipment utilization.
- Reasonably stable product demand.
- Product standardization.
- Part interchangeability.
- Continuous supply of material.
- Line layout has found its great field of application in assembly rather than in fabrication.

Product or Line Layout



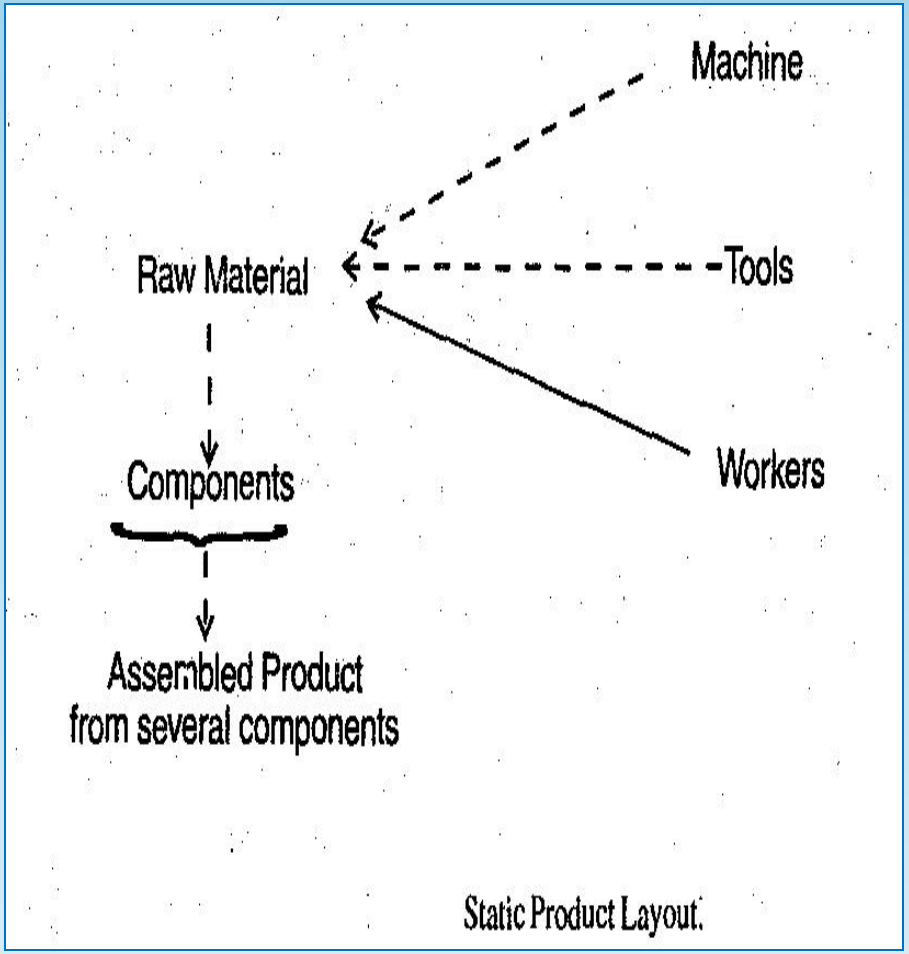
Product or Line Layout.

Mixed or Combined Layout

- It incorporates the benefits of process and product layout. It can be is developed as under :
- The production shops may be arranged by process layout, while the assembly is accomplished on line.
- In the product layout, some processes may be segregated from the product line, e.g. objectionable, hazardous, requiring special treatment and repetitive performance etc.

Static or Fixed Position Layout

- Adopted when work piece is very big or too heavy to move from one position to the other and is consequently fixed in one place.
- The machines and men move with respect to the work to perform the required operation.
- This type of layout is typical in custom order type production for example, in construction work, ship-building, in fabrication of [redacted]e vess[redacted]s, air craft.



Static Product Layout.

Static or Fixed Position Layout

FLOW PATTERN

- Men, machines and materials are the three basic inputs in the manufacturing process.
- Generally, men and machines tend to remain static while the materials move from one work station to another for the purpose of processing.
- The raw-materials pass through various paths till they are converted into finished products. While designing a new plant layout, generally the flow patterns are decided earlier and then a system of facilities is designed and built around the flow pattern.

FLOW PATTERN

The flow pattern of the material :

- Depends upon the type of layout. In the product layout, the material flow is short and smooth, while in the process layout it is long and involves many complexities.
- It is closely related with the type of the material handling equipment and the cost of material handling.
- It helps in minimizing the material handling cost by utilizing principle of minimum movements.
- It helps in eliminating bottlenecks, rushing, back-tracking etc., and ensures good supervision and control.
- It ensures effective utilization of plant capacity reducing work-in-process.
- It helps in reduction in operating cycle, time and results profitable returns on the investment.

Factors Governing Flow Pattern

- The flow pattern means the system to be adopted for the movement of raw-materials from the beginning and upto the point when it is converted into finished product.

Factors Governing Flow Pattern:

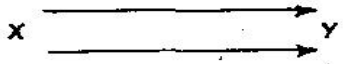
- External transport facilities.
- Number of products to be handled.
- Number of operations on each product.
- Number of units to be processed.
- Number of sub assemblies made up ahead of assembly line.
- Type of plant layout,
- Availability of floor space etc.

Types of Material Flow systems

- The material flow system can be broadly classified as
- Horizontal flow system
- Vertical flow system

- (i) **Horizontal Flow System.** The horizontal flow system is adopted on a shop floor in the single storey building. The starting point is the receiving (R) of raw material and the terminal point is the shipment (S) of finished goods or components. In between these two points the materials move from one work station to another for the purpose of processing. There are five basic types of horizontal flow systems :-
- I-Flow or Line Flow ..
- L-Flow
- U-Flow
- S-Flow
- 0-Flow
- In addition combination horizontal flow systems are
- Combination of I and U type flow
- Combination of I and S type flow

Flow patterns

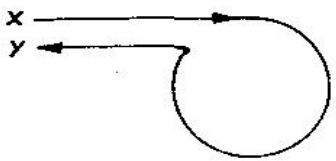


(*a*) Line flow

– Simplest, material enters at one end (*X*) and leaves at other end (*Y*). It is preferred in buildings having long lengths and smaller widths.

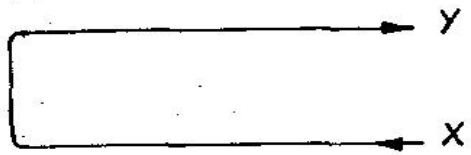
(*b*) *L* type flow

– Resembles line flow and is used where buildings are more wide but less long as compared to line flow type buildings.



(*c*) Circular flow

– Preferred for rotary handling systems. Different work stations are located along the circular path. Raw material enters at *X* and finished goods come out from *Y*.



(*d*) *U* type flow

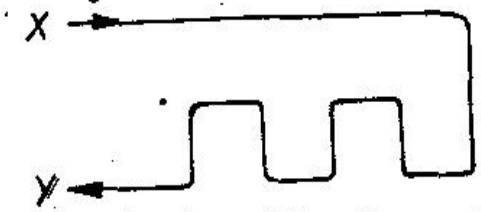
– Supervision is simpler as compared to (*a*) and (*b*) above. Raw material entrance and finished goods exit is on the same side. (*c*) and (*d*) are preferred in square-shaped buildings.

(*e*) *S* or inverted *S*

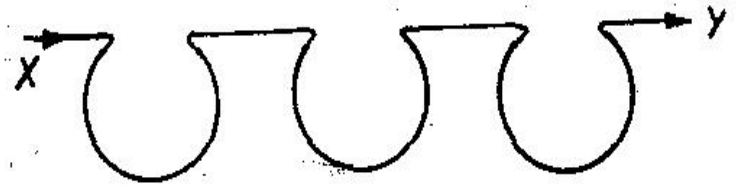
– Preferred for production lines longer than (*d*) and in square shaped buildings. The system is compact, space has been better utilized and supervision is efficient.

Flow patterns

(*f*) Combination of *U* and line flow pattern



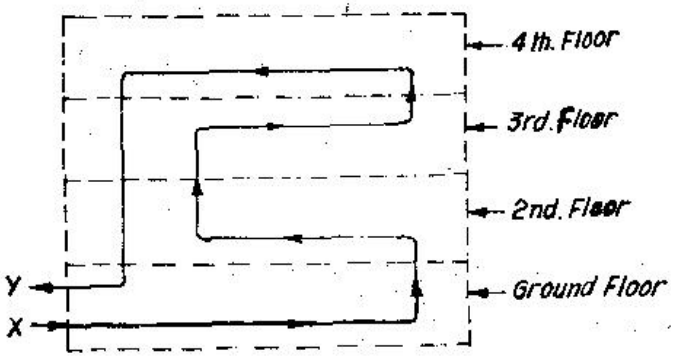
(*g*) Combination of line flow and *S* type of pattern



As compared to line flow, this system needs smaller building lengths.

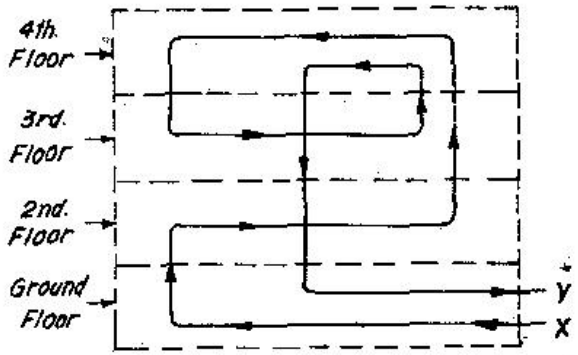
(*h*) Combination of line flow and circular type

Flow patterns



(*i*) Processing upwards

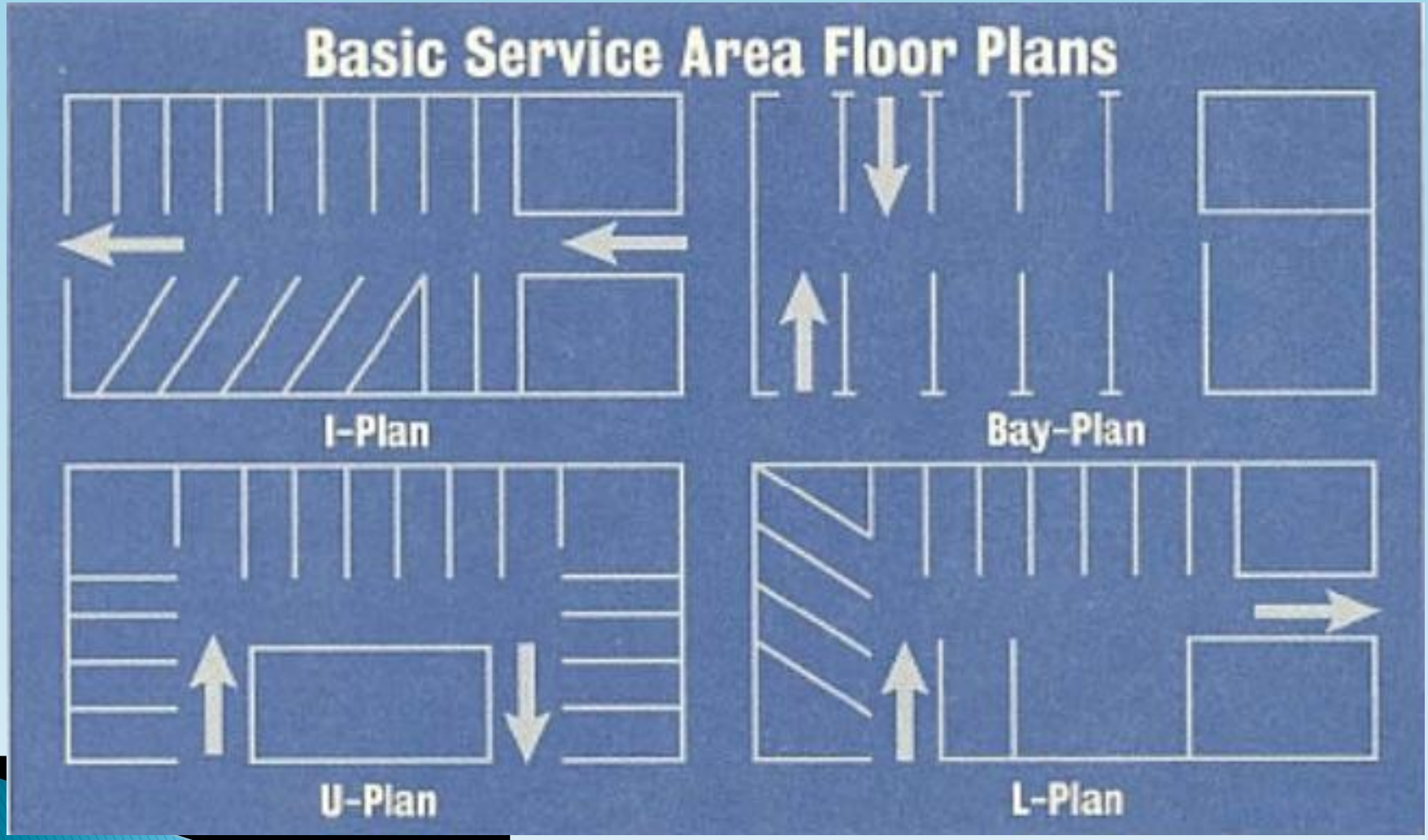
– The material may be processed while moving upwards or downwards in multi-storey buildings. In processing downward, gravity helps to bring the material down but first of all the whole material has to be taken to the top storey. An industry manufacturing plane glass may go for an upward type of flow.



(*j*) Retraction type of flow in multi-storey buildings.

– It involves more material handling cost as compared to (*i*) but finds better space and equipment utilization.

Floor Plan – Car Service Centre



Types of Material Flow systems

Vertical flow system

- It is used in multistoried buildings.
- It is used when less floor area is available and processing is done on lighter material.
- It is also used in continuous process industries.
- Advantage of gravity is taken in material movement.

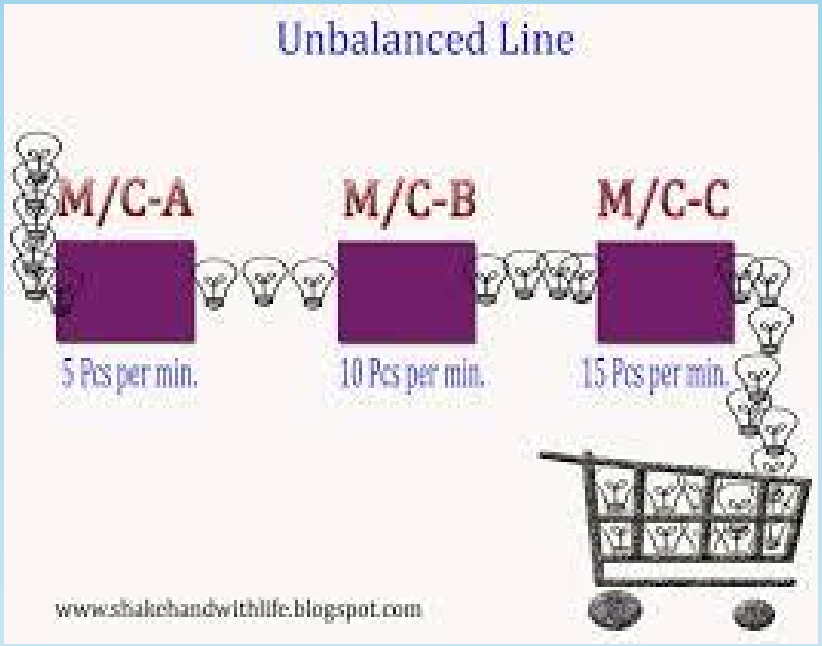
LINE BALANCING

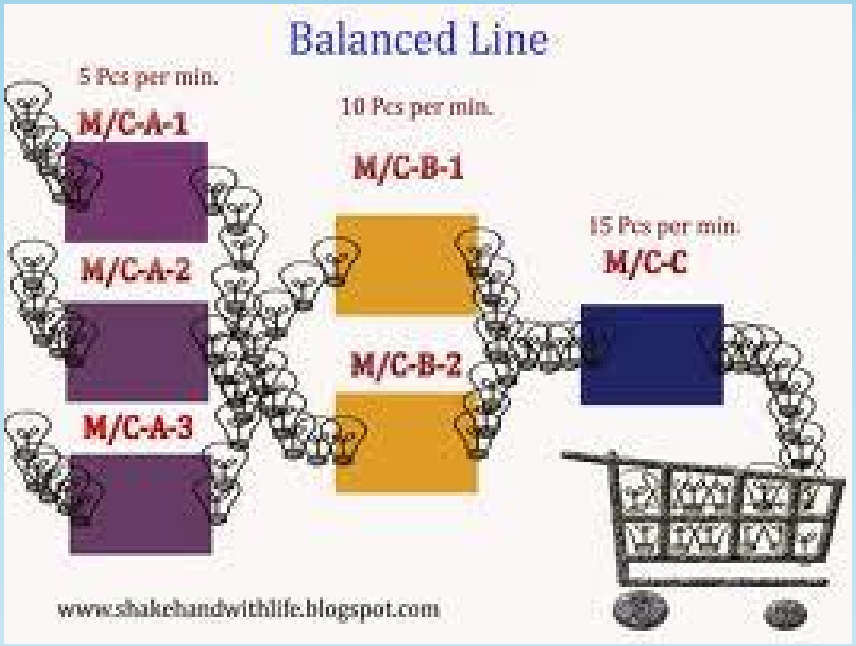
- Line balancing in a layout means balancing the production line or an assembly line. The problem of line balancing is particularly important in product layout.

- It may arise due to the following factors:
- The finished product is the result of many sequential operations.
- The production capacity of each machine in the sequence is not identical.

- The actual production in the line will be decided on the basis of the machine with the maximum production capacity. The production capacity of the other machines in the line will be adjusted through the increase in the number of machines.

LINE BALANCING





LINE BALANCING

- The main objective of line balancing is to distribute tasks evenly over the workstation so that idle time of man and machines is minimized.
- Line balancing aims at grouping the facilities (or tasks) and workers in an efficient pattern in order to obtain an optimum balance of the capacities.
- For perfect line balancing it is essential that the output of fastest machine is multiple of the output of the remaining other machines. But, this may not be always possible and hence, it would be difficult to eliminate the idle capacity totally. In such cases some other tasks are assigned to the machines remaining idle.
- Thus, the tasks are grouped so that their total time is preferably equal to or a little lesser than the time available at each work station in order to reduce idle

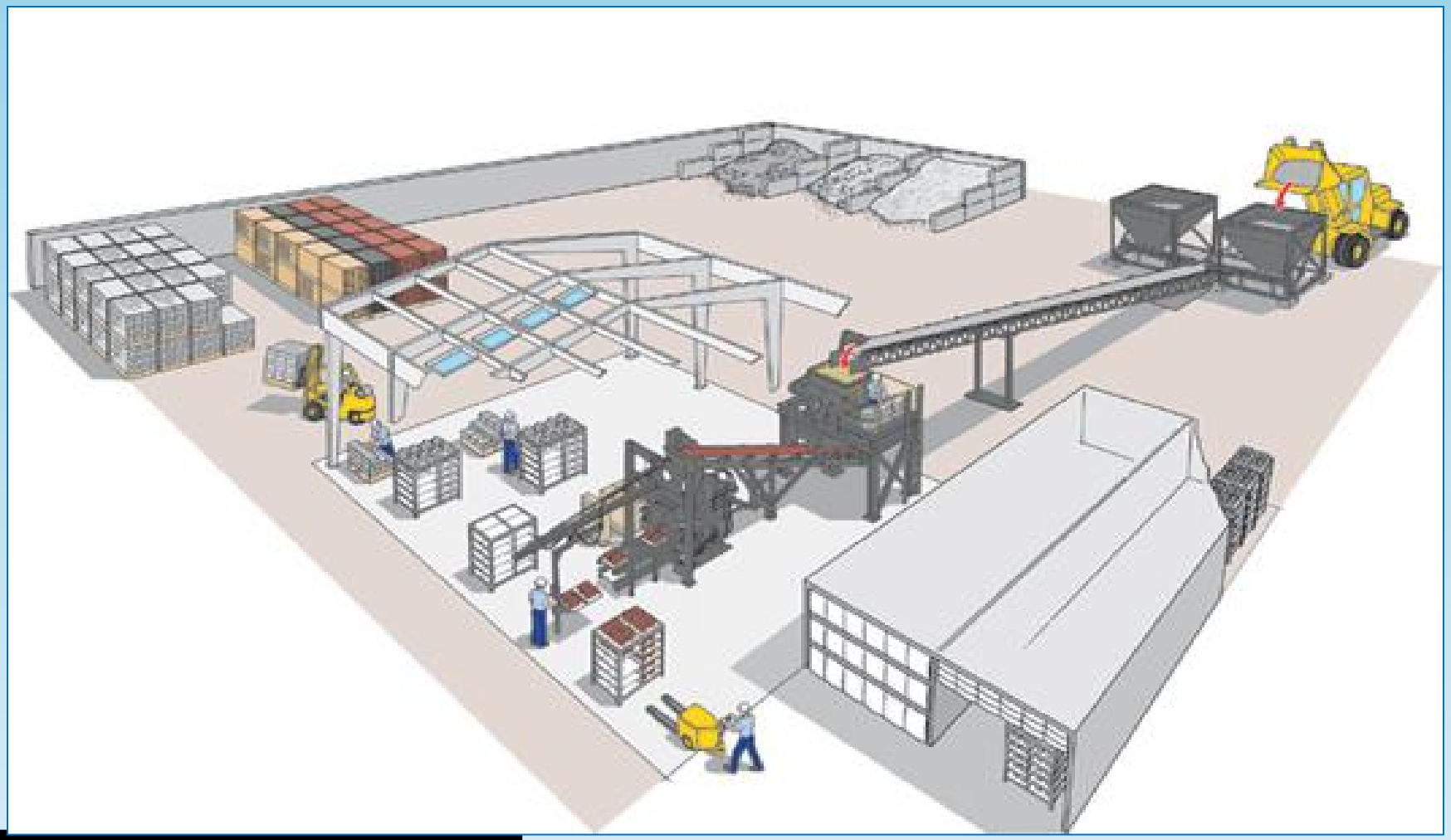
LINE BALANCING

- If the cost of over-production exceeds the cost of idle capacity in the unbalanced line, then attempts are made to solve the problem in some other manner as follows :
- Another product line enabling the use of idle capacity of the first line could be run close to it.
- To transfer the work elements from overloaded machines to some other machines somewhere else in the line.
- If negligible part of some machine capacity is required to be utilized then the job may be performed with some outside jobbing firms.
- Alternately, machines with lower capacity utilization rate, may be used to perform the jobs of other manufacturers through sub-contracting.
- For solving the line balancing problems, number of methods are available, for example, linear programming, dynamic programming, PERT, CPM etc. Only those solutions should be sought which command the maximum economic benefits

The symptoms of a layout in need of redesign

- Congestion of materials, components and assemblies.
- Excessive amount of work in process.
- Poor utilization of space.
- Long transportation lines.
- Production bottlenecks of certain machines while similar or identical machines have idle time.
- Excessive handling by skilled operators.
- Long production cycles and delays in delivery.
- Mental or physical strain on operators.
- Difficulties in maintaining effective supervision and control.
- A bad plant layout would lead to loss of efficiency, waste of time and energy, inconveniences and botherations in the actual operations and in the process of production.
- A good layout ensures orderly and efficient arrangement of work facilities and personnel.

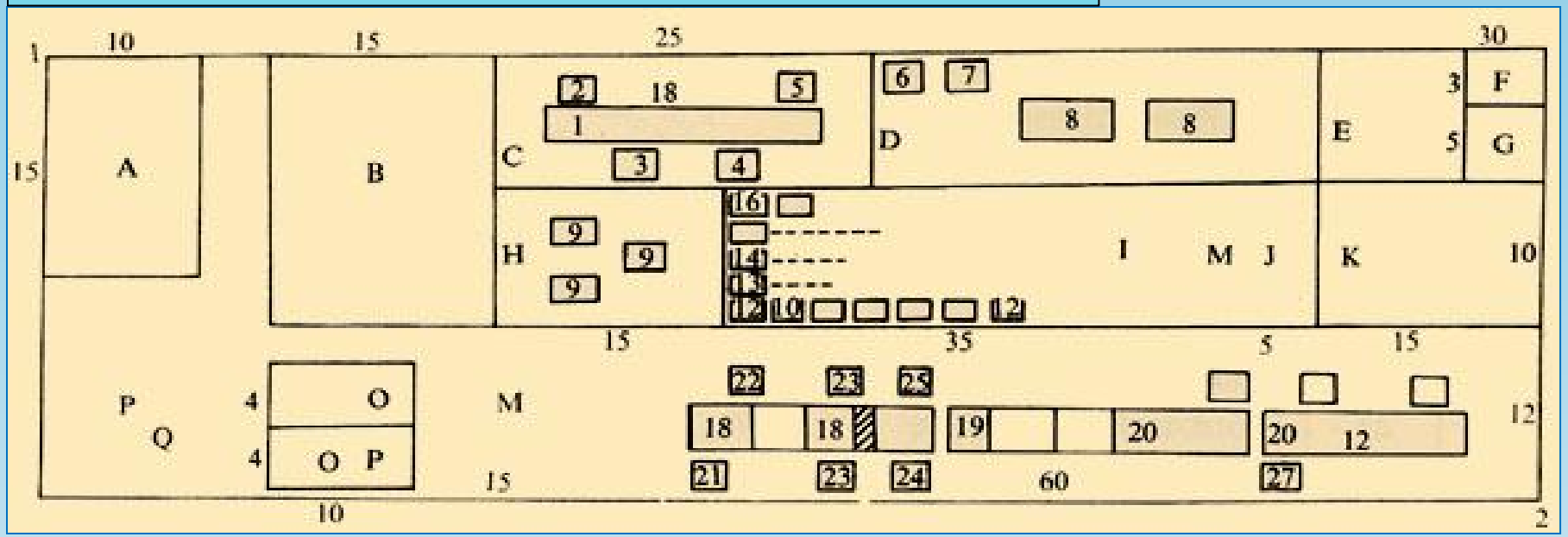
Plant Layout For Concrete Production



Plastic Footwear Making Plant

- A shoe making plant located in any region where adequate supplies of the raw materials needed are easily accessible, should have no problem making money, providing the area in question is developed enough to provide electrical power, adequate ways and means of transportation, and a capable work force.

Plastic Footwear Making Plant

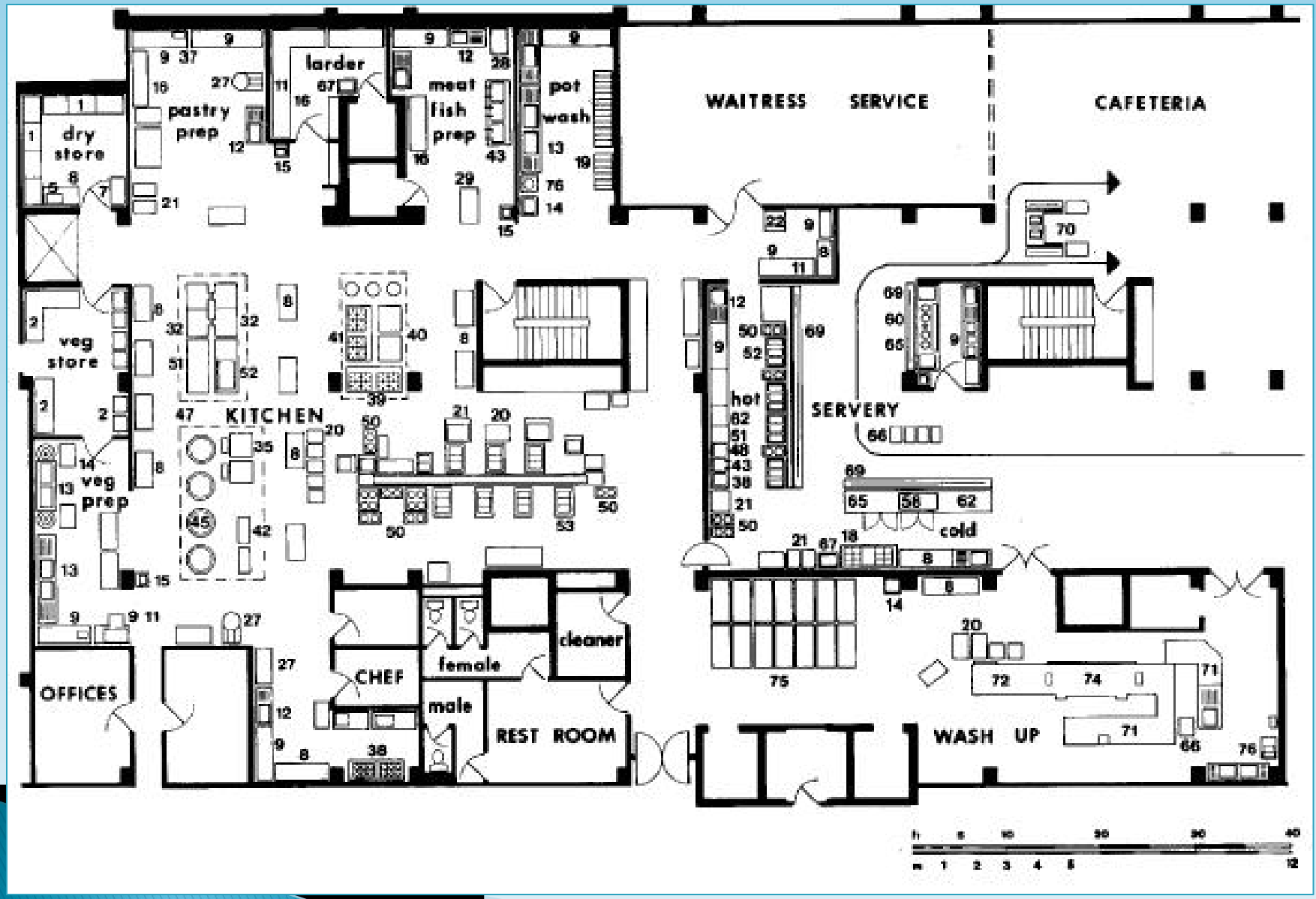


A	Office	I	Stitching division
B	Raw material storage area	J	Hand vamping division
C	Insole molding division	K	Semifinished product warehouse
D	Injection molding area	L	Production Line Division Storage area
E	Painting division	M	Products Warehouse
F	Utility room (Compressor)	N	Quality control and factory office
	m	O	Research and development lab
	area	P	Parking lot

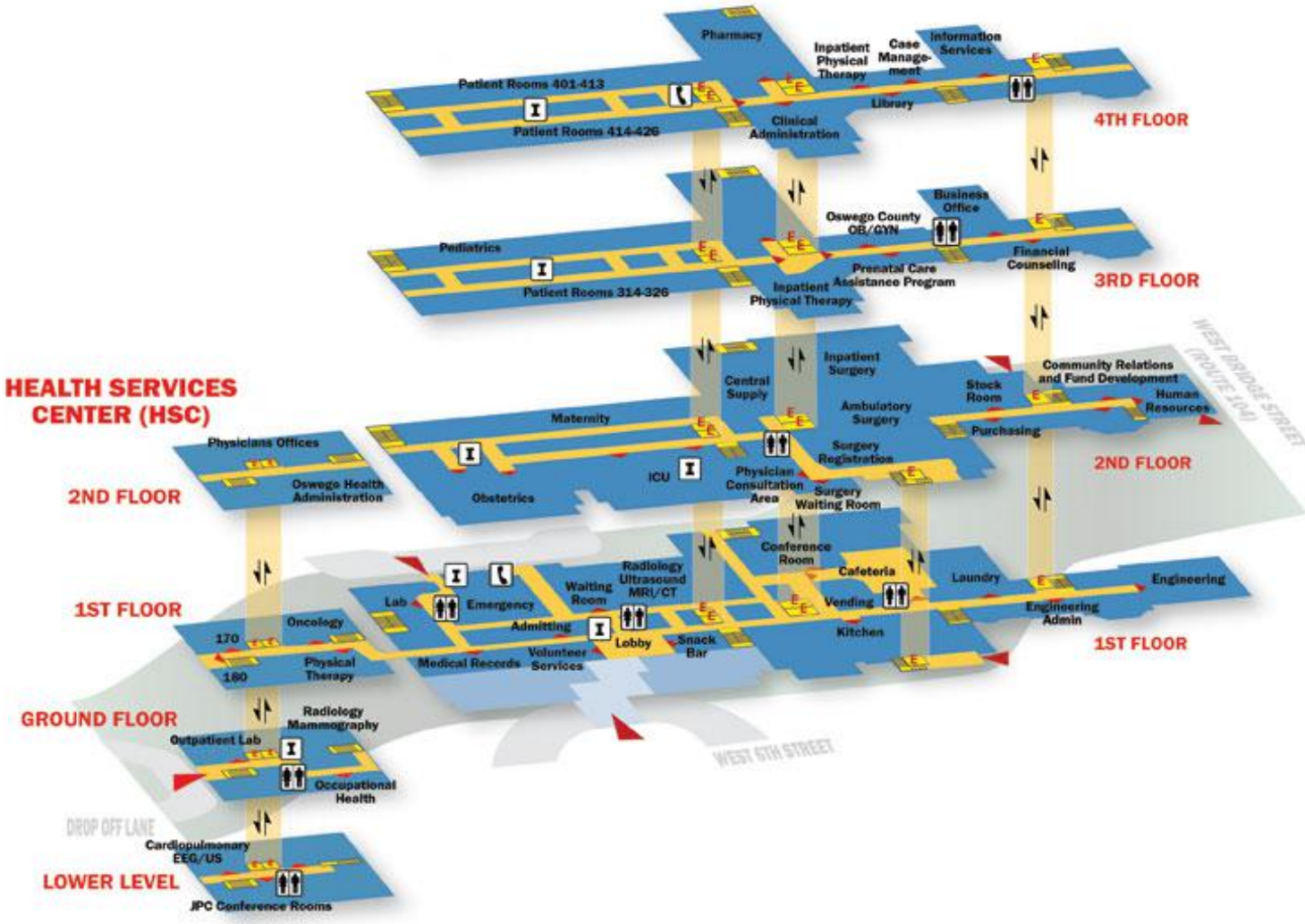
The Service industries

- The Service industries involve the provision of services to businesses as well as final consumers. Such, services include accounting, tradesman ship (like mechanic or plumber services), computer services, restaurants, tourism, Advertising, Entertainment , Financial services, Healthcare, Hospitality industry , Insurance , Marketing , Public services , Real estate, Service companies, Tourism, Travel etc.

Restaurant layout (Services)



Layout of a hospital (Services)



Question Bank – Plant Layout

- Q 1. Define plant layout. State the principles of plant layout.
- Q 2. Describe the objectives of good plant layout.
- Q 3. Describe the factors influencing plant layout.
- Q 4. What are the situations in which layout problem may arise ?
- Q 5. Explain product layout and process layout. State the factors which influence the selection of one or the other.
- Q 6. What is line balancing. State its objective.
- Q 7. What are the symptoms of bad plant layout.
- Q 8. What is a static of fixed position layout.
- Q 9. What is a flow system ? How they are classified ? What are the factors Governing Flow Pattern? Sketch any four flow patterns.
- Q 10. Explain plant layout tools and techniques.
- Q 11. Each student has to make Labeled Layout of a plant (manufacturing, repair shop or any services sector) on a A4 size paper.

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