

PLANT AND SHOP LAYOUT

3.1 INTRODUCTION

'Shop Layout' forms an integral part of 'Factory Planning' or 'Plant Layout' which, in itself, is a very specialised job. *Plant layout* is an important tool of 'Scientific Management' which, till recently, was almost a neglected factor in most of the industrial enterprises in our country. However, it is fortunate to see it gaining its due importance in all the enterprises now. This, being a very wide topic, cannot be dealt with in detail here. Still, it would not be out of place to give a brief account of the same.

The term **Plant Layout** has been defined in many ways considering various different aspects, but in very simple terms it can be defined as follows :

Plant Layout is such a systematic and effective functional arrangement of different departments, machines, equipment and services of an organisation that will facilitate the processing of the proposed or undertaken product in the most efficient and economical manner in the minimum possible time.

The term '*Plant Layout*' incorporates all the aspects connected with the enterprise, viz., grounds, buildings, machinery, equipments, departments, methods of manufacturing, factory services, material handling, flow of production, working conditions, hygiene, labour and shipment of goods, etc. The term '*Plant Layout*' does not necessarily mean planning a new enterprise only. It implies all the following :

1. Minor improvements, here and there, in the existing layout.
2. Expansion of the existing plant.
3. Re-layout of the existing plant.
4. Layout of a new (proposed) plant.

Objectives of Plant Layout

Whatever be the mode of plant layout, the endeavour always is to arrange the buildings, men and materials, in such a way that the following objectives are efficiently served :

1. The material has to move a minimum distance.
2. There is a smooth flow of the product in the plant.
3. The entire space of the plant is fully utilised.
4. The layout provides adequate safety and satisfaction to the plant workers.
5. It provides for enough flexibility in the arrangement of the above factors, so as to suit minor future changes, if any.
6. It facilitates an effective supervision.
7. Over and above all, it integrates all the above factors in such a way that the best compromise and coordination is achieved among them.

Advantages of a Good Layout

A good many advantages and benefits are offered by a good plant layout, of which a few prominent ones are given below :

1. The floor area is effectively and economically utilised.
2. The rate of production is increased and less men and machine hours are used per unit of production.
3. The material handling time is minimised.
4. The usual production delays are avoided.
5. The men, machinery and factory services are more effectively utilised.
6. The overall production time is reduced.
7. A fairly large amount of paper work is eliminated.
8. The indirect expenses are considerably reduced.
9. A better utilisation of labour is provided.
10. The inventory work for material is cut down considerably.
11. A better supervision is facilitated and confusion reduced.
12. Any congestion due to men, machines or material is avoided.
13. An adequate flexibility in arrangement is provided to suit the future changes, if any.
14. It promotes better planning and effective control.
15. It facilitates a better and easier maintenance of plant and machinery.
16. It provides safer and healthier working conditions, thereby improving the morale of the workmen.

17. It provides the material as well as psychological satisfaction to the workers.
18. It results in better wages to the workers and enhanced overall efficiency of the plant.

3.2 IMPORTANT CONSIDERATIONS

When a large industrial undertaking is initially planned a number of important considerations are made before taking a final decision. The common factors affecting this decision are :

1. Availability of space.
2. Availability of power.
3. Availability of water.
4. Availability of raw material.
5. Climatic conditions.
6. Means of communication and transport facilities.
7. Marketing facilities for the planned product.
8. Possibility of utilisation and sale of the process wastes and by-products of the planned industry.
9. Effect of ancillary industries.
10. Availability of skilled and unskilled labour locally.
11. Local taxes and similar other economic considerations.

Once a final decision has been taken, regarding the size and location of the enterprise, the next step is to plan the internal layout of the factory *i.e.*, to plan-out the sequence of different shops and their locations accordingly. The same is generally affected by the following :

1. Specifications of material and product.
2. Manufacturing processes.
3. Type of production.
4. Material handling facilities.
5. System and facilities for storing.
6. Inter-dependability of one shop over the other.
7. Service facilities.
8. Lighting and ventilation.

After finalising the above sequence, the internal arrangement of the equipment of different shops is decided next. This is called **Shop Layout**. The following factors affect this layout :

1. Size and type of equipment.
2. Number of machines to be installed.
3. Floor area required for working on each machine.

4. Use of individual machine.
5. Power requirements for the machines.
6. Requirements of factory services.
7. Sequence of operations to be followed.
8. Sound and uniform get-up.
9. Accessibility to all the machines.
10. Proper supervision and control.
11. Type of drive used—*i.e.*, group or individual.
12. Safe working conditions.
13. Provision of stores within the shop, *i.e.*, for tools, instruments, finished parts and consumable materials, etc.

3.3 TYPES OF LAYOUTS

The above conditions and requirements have led to different types of layouts which may be broadly classified as follows :

1. Fixed position layout

In this type of layout the major part of an assembly or material remains at a fixed position and all its accessories, auxiliary material, machinery and equipment needed, tools required and the labour are brought to it to work at site. Thus, the location of the major component or material is not disturbed till the product is ready for despatch.

Merits and Demerits

This type of layout is mostly adopted for extremely large items manufactured in very small numbers, *e.g.*, ships, aeroplanes, etc. The main advantages of this type of layout are :

1. Minimum movement of material, men and tooling during process.
2. The type of product and the related processes can be easily changed without any change in the layout.

Demerits

1. Equipment handling cost is high.
2. Labour and equipment is not fully utilised.

2. Process or functional layout

In this type of layout, similar machines or operations are grouped together, so that all the operations of same type are performed at the same place always. For example, all the lathes may be grouped together to do turning and threading etc., all drilling machines in one area to do drilling work, all buffing and polishing machines at one place to do surface finishing work, and so on.

This type of layout is usually preferred for the industries involved in 'job order' type of production and manufacturing and/or maintenance activities of non-repetitive type. This type of layout is shown in Fig. 3.1, which illustrates the movement for two products A and B. The operations required for these products in order of sequence are as follows :

Product A—Turning, Milling, Broaching, Shaping, Drilling, Inspection.

Product B—Forging, Turning, Shaping, Drilling, Heat treatment, Inspection.

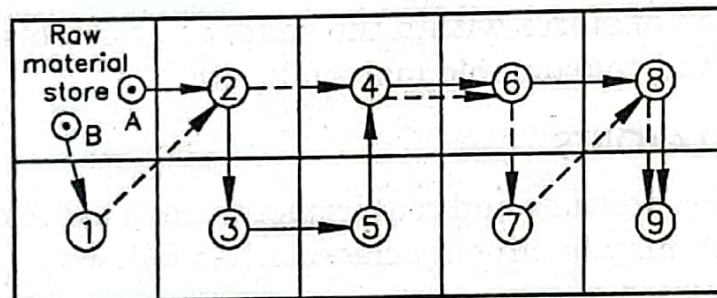


Fig. 3.1. Process layout showing product movements of products A and B.

1. Forging, 2. Turning, 3. Milling, 4. Shaping, 5. Broaching, 6. Drilling,
7. Heat treatment, 8. Inspection and 9. Finished parts store.

Advantages and Disadvantages

Advantages

1. Fewer machines needed. Hence, smaller capital investment required.
2. Workers' monotony broken, because they are required to handle different varieties of jobs. Hence, the work becomes more interesting.
3. Because of the workers and their supervisors attending to the same type of machinery and operations repeatedly, the product quality is better.
4. The available machinery and equipment are better utilised.
5. Health hazards in one section, if any, do not affect the workers of the other section.
6. Greater flexibility in work allotment.

Disadvantages

1. Requires more floor area for layout.
2. Requires large in-process inventory.
3. Material handling time and, therefore, the corresponding cost is higher.

4. Production control is relatively difficult.
5. Material handling process cannot be easily automated.
6. Total job completion time is more.

3. Line production or Product Layout

In this type of layout all the machines are arranged in a line according to the sequence of operation, *i.e.* each following machine or section is arranged to perform the next operation to that performed by its proceeding machine or section. It is an ideal form of layout in which the handling time is minimum.

This type of layout is commonly used in *continuous production*, which involves a continuous flow of material from raw material stage to the finished product stage. A sample **product (or line) layout** is shown in Fig. 3.2. In this, the operations required in sequence are Forging, turning, drilling, milling, grinding and inspection before the product is sent to the finished goods store for packing and shipment.



Fig. 3.2. A sample product layout showing different departments and continuous product flow.

1. Raw material store, 2. Forging, 3. Turning, 4. Drilling, 5. Milling,
6. Grinding, 7. Inspection, 8. Finished goods store.

Advantages and Disadvantages

Advantages

1. Relatively less floor area required.
2. Production planning and control is easier and better coordinated.
3. Smaller in-process inventory needed.
4. Work flow is continuous and smooth.
5. Material handling process can be easily automated and, therefore, the corresponding time and cost reduced.
6. Overall product completion time is less.

Disadvantages

1. Less flexibility in layout.
2. Higher capital investment needed.
3. Increase in production possible only to a limited extent.
4. The rate of production is largely governed by the rate of the slowest machine. Thus, for increasing the production rate a higher capital investment is required to install more such machines so as to balance the production line.

The relative comparison between these two types of layouts, *i.e.*, Process Layout and Product Layout is shown in Table 3.1.

Table 3.1 Relative comparison of Process and Product Layout

<i>Sl. No.</i>	<i>Criteria</i>	<i>Process Layout</i>	<i>Product Layout</i>
1.	Flexibility of changes in layout.	Better	Too less
2.	Capital investment required.	Less	More
3.	Product Quality.	Better	Poorer
4.	Utilisation of available machinery	Better	Poorer
5.	Monotony in working.	Less	More
6.	Flexibility in work allotment to workman and machinery.	More	Less
7.	Space required for same amount of production.	More	Less
8.	Ease and effectiveness in production planning and control.	More difficult	Better and easier
9.	In-process inventory required.	Large	Small
10.	Time taken in completion of product.	More	Less
11.	Material handling movements and costs.	More	Less
12.	Ease of automation in material handling	Not appreciable	Full automation possible
13.	Need of Inspection.	More	Less
14.	Work flow	Restricted	Smooth and continuous

4. Combination Layout (or Group Layout)

Because of the inherent advantages and disadvantages associated with both the Process Layout as well as Product Layout the best results can be obtained by combining Salient features of both these layouts into a single one, and this is known as a **Combination Layout**. These days most of the manufacturing industries have adopted this type of layout for obvious reasons. In this type of layout a set of machinery or equipment is grouped together in a section, and so on, so that each set (or group) of machines or equipment is used to perform similar operations to produce a family of components. Since this type of process layout incorporates

the principle of *group technology*, this layout is known as *Group layout* as well. The flow of product follows a *Product layout* sequence. Hence, the name **Combination (or Group) Layout**.

A sample *combination layout* for manufacturing forged crankshafts is shown in Fig. 3.3, wherein the combination of both *Process Layout* and *Product Layout* is quite clear.

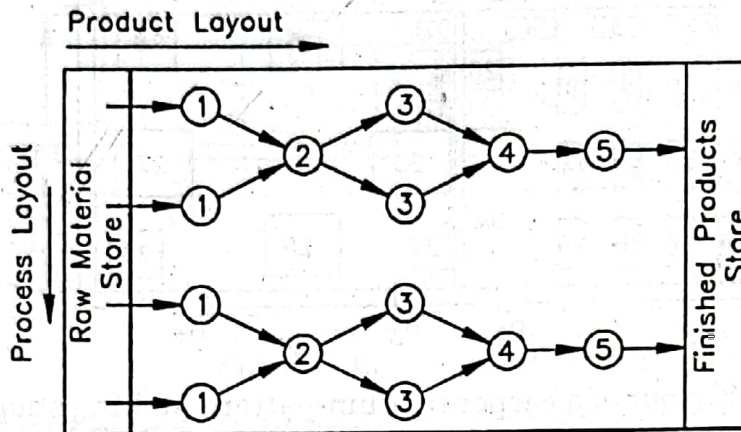


Fig. 3.3. A combination layout for manufacturing different sizes of crankshafts.

1. Forging hammers, 2. Inspection, 3. Journal grinding, 4. Heat treatment, 5. Final inspection.

Some typical layouts are given in the following pages which, it is hoped, will prove as useful guides. However, necessary amendments may be made according to the individuals needs.

3.4 CARPENTRY AND PATTERN-MAKING SHOP LAYOUT

It is one of the basic shops which forms an important part of all manufacturing, repairs or training workshops. All sorts of carpentry and joinery work, pattern making, corebox making and cabinet work is done in this shop. The common equipments of this shop are listed below and a layout is shown in Fig. 3.4.

List of equipment

	<i>Shown at</i>
(i) Work benches 150 cm x 90 cm (with two vices each)	Nos. 5 to 19
(ii) Wood turning lathes	Nos. 1 to 4
(iii) Double-ended grinder	No. 22
(iv) Band saw	No. 23
(v) Circular saw	No. 25
(vi) Universal woodworking machine	No. 29
(vii) Circular saw sharpener	No. 24
(viii) Thickness planer	No. 27
(ix) Moulding machine	No. 26
(x) Chain mortiser	No. 28

Other details of layout shown

- | | |
|--|--------|
| (a) Supervisor's room | No. 21 |
| (b) Shop store for tools and material | No. 20 |
| (c) D_1, D_2, D_3, D_4 and D_5 are the entrances | |

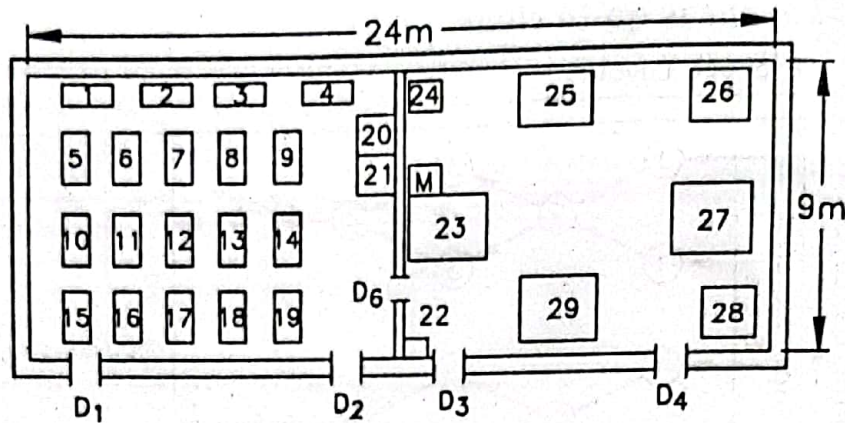


Fig. 3.4. Layout of a carpentry-cum-pattern making shop.

3.5 FOUNDRY SHOP LAYOUT

It is another basic shop which enjoys an indispensable position in workshops. In this shop, all types of ferrous and non-ferrous castings are made in dry, green and loam sands. Core-marking is another important work done in this shop. The common equipment and other details of the layout are listed below and the corresponding layout shown in Fig. 3.5.

	<i>Shown at</i>
(i) Foundry cupola of required capacity	No. 7
(ii) Blower of proper capacity for cupola	No. 6
(iii) Pit furnaces	Nos. 9 and 10
(iv) Oil fired tilting furnace	No. 8
(v) Drying oven	No. 5
(vi) Bench for bench moulding	No. 2
(vii) Space for floor moulding	No. 1
(viii) Space for core making	No. 4
(ix) Space for fettling and finishing	No. 3
(x) Store for patterns and tools etc.	No. 11
(xi) Supervisor's room	No. 12
(xii) Coke store	No. 13
(xiii) Equipment like moulding boxes, crucibles and ladles etc. can be suitably accommodated.	

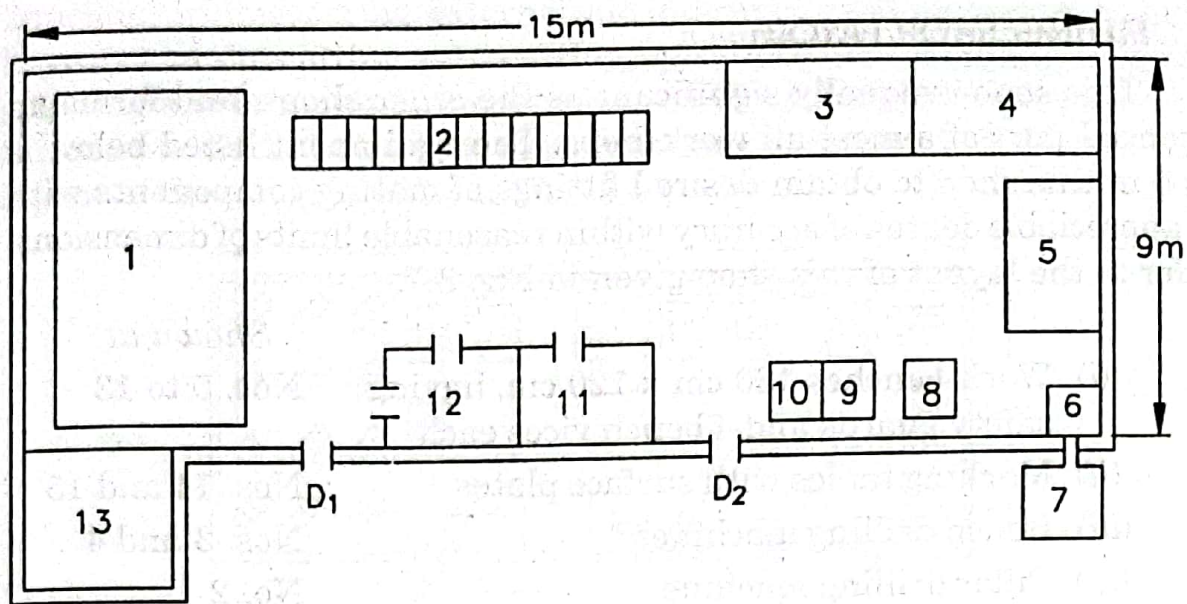


Fig. 3.5. Layout of a foundry shop.

3.6 SMITHY SHOP LAYOUT

It is another important shop in which various forging operations like upsetting, drawing out, forge-welding, bending, cutting, punching and drifting, swaging and cold and hot riveting can be performed. The main equipment required for a medium size shop is given below and the corresponding layout shown in Fig. 3.6.

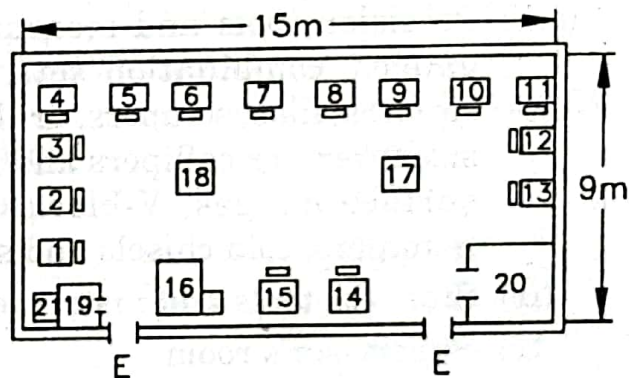


Fig. 3.6. Layout of a Smithy shop.

- | | |
|---|-----------------|
| | <i>Shown at</i> |
| (i) Smith's forges | Nos. 1 to 15 |
| (ii) Centrifugal air blower | No. 21 |
| (iii) Power hammer | Nos. 16 |
| (iv) Swage blocks | No. 17 and 18 |
| (v) Anvils—Equal in number to forges (<i>shown by small rectangles in the layout</i>). | |
| (vi) Pneumatic reverting machine with a set of snaps of suitable sizes | |
| (vii) Sets of hand tools <i>viz.</i> , hammer, tongs, chisels, hardies, set hammers, fullers, swages, flatters snaps and bick iron etc. | |
| (viii) Stores for tools and raw material | No. 19 |
| (ix) Supervisor's room | No. 20 |

3.7 FITTING SHOP LAYOUT

This shop is equally significant as the other shops, and forms an essential part of almost all workshops. The equipment listed below is used in this shop to obtain desired fittings of mating components with an appreciable degree of accuracy within reasonable limits of dimensions. Refer to the layout of this shop given in Fig. 3.7.

	<i>Shown at</i>
(i) Work-benches 180 cm × 120 cm, having safety guards and 4 bench vices each	Nos. 5 to 13
(ii) Marking tables with surface plates	Nos. 14 and 15
(iii) Bench drilling machines	Nos. 3 and 4
(iv) Pillar drilling machine	No. 2
(v) Arbor Press	No. 16
(vi) Double ended grinder	No. 1
(vii) Sets of sine bars and gauge blocks	
(viii) Precision tools and measuring instruments like callipers, gauges, combination sets, bevel squares, engineer's try-squares, files, scrapers, drill bits, taps and die sets of various sizes, vernier callipers and micrometers of different ranges, surface gauges, V-blocks and clamps, centre punches, hammers, cold chisels and spanners etc.	
(ix) Store for tools and instruments etc.	No. 17
(x) Supervisor's room	No. 18

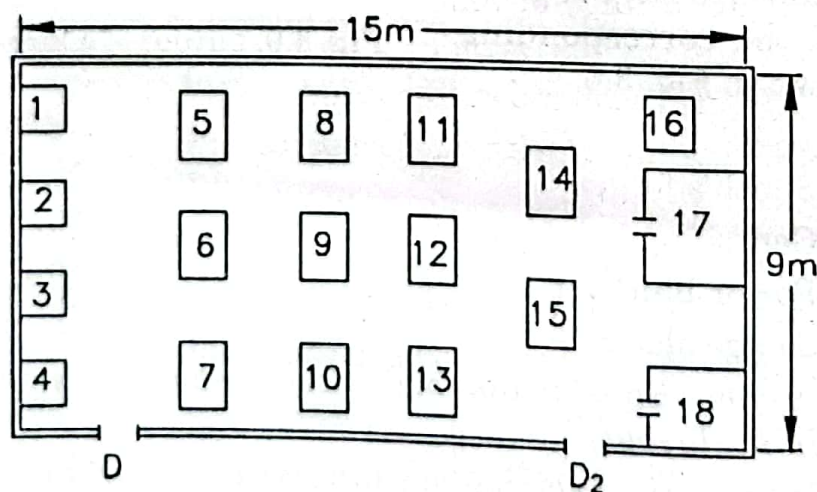


Fig. 3.7. Layout of a Fitting shop.

3.8 MACHINE SHOP LAYOUT

It is actually the life of all good workshops and involves the maximum initial investment as compared to other shops. All the common machining operations like simple turning, step, radius and taper turning,

knurling, drilling, boring, external and internal threading, facing, planing, keyway and slot cutting, gear cutting, spiral and helical milling, shaping, grinding and other similar operations can be successfully performed in this shop with the help of the machines and equipment listed below. The layout of this shop is given in Fig. 3.8.

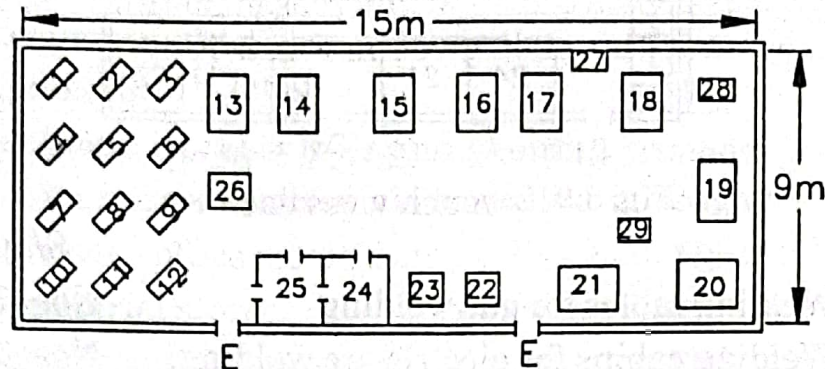


Fig. 3.8. Layout of a Machine shop.

	<i>Shown at</i>
(i) S.S.S.C. lathes	Nos. 1 to 10
(ii) Capstan or turret lathe	No. 11
(iii) Single spindle automatic lathe	No. 12
(iv) Shapers	Nos. 13 and 14
(v) Universal milling machine	No. 15
(vi) Vertical boring machine	No. 18
(vii) Planing machine	No. 21
(viii) Power hacksaw	No. 19
(ix) Pillar drilling machine	No. 17
(x) Radial drilling machine	No. 28
(xi) Wet and dry tool grinder	No. 27
(xii) Universal tool and cutter grinder	No. 20
(xiii) Marking tables with surface plates	Nos. 26 and 29
(xiv) Surface grinder	No. 22
(xv) Cylindrical grinder	No. 23
(xvi) Stores for tools and instruments	No. 24
(xvii) Sufficient number of tools, cutters and instruments etc.	
(xviii) Supervisor's room	No. 25
(xix) Bench drilling machine	No. 16

3.9 WELDING SHOP LAYOUT

The given layout (Fig. 3.9) is of Gas and Electric Welding shop. The common equipment and other requirements of this shop are as follows :

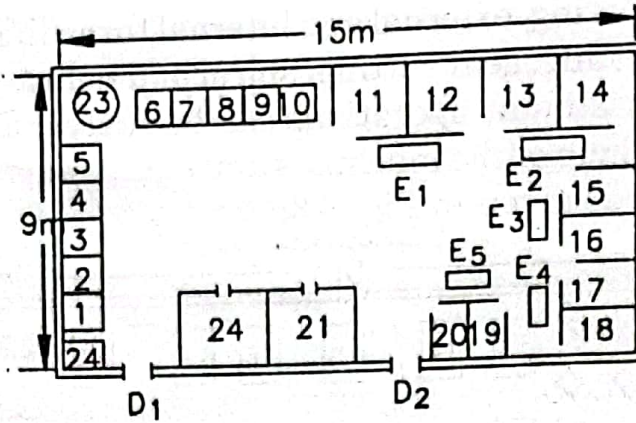


Fig. 3.9. Layout of a welding shop.

Shown at

- | | |
|---|------------------|
| (i) Welding tables for gas welding | Nos. 1 to 10 |
| (ii) Welding cabins for electric arc welding, carrying one table each | Nos. 11 to 20 |
| (iii) Oxygen and acetylene gas cylinders (for H.P. welding and cutting) | |
| (iv) Acetylene generator for L.P. plant | No. 23 |
| (v) Arc welding transformers | Nos. E1, E2 & E3 |
| (vi) Electric welding motor generator sets | Nos. E4 & E5 |
| (vii) Grinder (Double ended) | No. 24 |
| (viii) Gas cutting equipment | |
| (ix) Electric welders tool kits | |
| (x) Store for tools and consumable material | No. 22 |
| (xi) Supervisor's office | No. 21 |
| (xii) D ₁ and D ₂ are the entrances | |

3.10 SHEET METAL AND PAINTING SHOP LAYOUT

The essential equipment of these shops is listed below and the layout shown in Fig. 3.10.

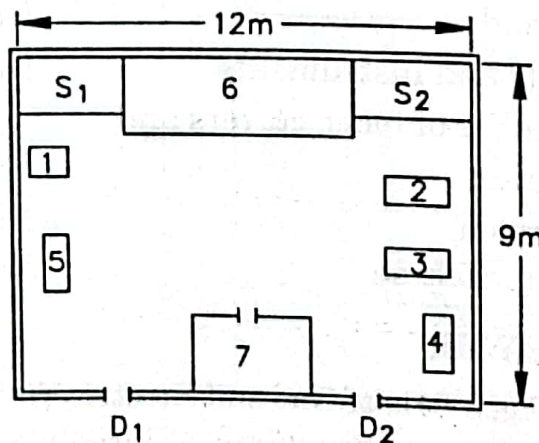


Fig. 3.10. Layout of a sheet-metal and painting shop.

	<i>Shown at</i>
(i) Shearing machine	No. 2
(ii) Folding and beading machine	No. 4
(iii) Circle cutting machine	No. 3
(iv) Buffing and polishing machine	No. 5
(v) Spray painting machine with air compressor	No. 1
(vi) Sheet metal workers tools and painting brushes	
(vii) Space for hand and spray painting	No. 6
(viii) Supervisor's office	No. 7
(ix) Raw material stores	S1
(x) Finished components stores	S2
(xi) D_1 and D_2 entrances.	

3.11 PLUMBING AND MASONARY SHOP LAYOUT

The essential equipment for these shops is given below and the layout shown in Fig. 3.11. The proposed equipment is sufficient for carrying out common operations in pipe work like cutting, bending and threading etc.

	<i>Shown at</i>
(i) Pipe bending machine	No. 1
(ii) Pipe threading machine	No. 2
(iii) Work benches with pipe vices	Nos. 3, 4 & 5
(iv) Mason's tools kits	
(v) Pipe wrenches and chain wrenches	
(vi) Pipe taps and die sets	

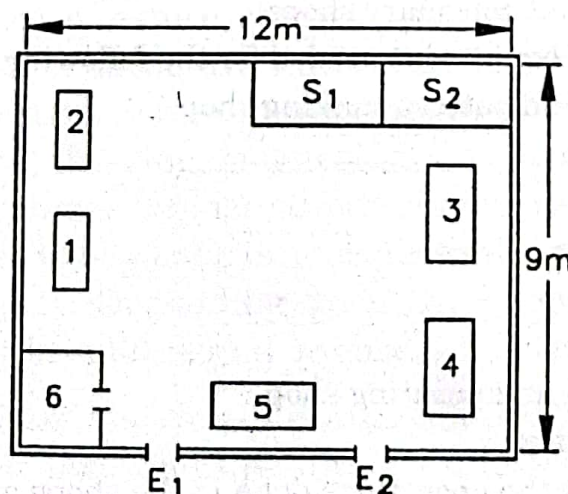


Fig. 3.11. Layout of plumbing and masonry shop.

- (vii) Handsome stock of pipe connections like sockets, bends, elbows, tees and nipples, run on cocks, valves, etc.

- (viii) Supervisor's office
 (ix) Stones
 (x) E_1 and E_2 are the entrances.

No. 6
 S_1 and S_2

TEST QUESTIONS

1. What do you understand by the terms 'Plant layout' and 'Shop layout'?
2. What are the main objectives of plant layout?
3. What are the advantages of a good layout?
4. What general considerations are made in preparing the layout of an industrial concern?
5. What factors govern the preparation of shop layout?
6. What factors govern the relative locations of different shops in a concern?
7. How do you classify the different types of layouts? Explain in brief.
8. Give a brief account of Fixed position layout, stating its merits and demerits.
9. Describe a product layout and explain its principle with the help of a neat diagram. What are its advantages and disadvantages?
10. Explain a process layout, stating its advantages and disadvantages.
11. Compare process layout with a product layout.
12. What is a Combination or Group layout? Why it is known so and what are its main advantages?
13. Draw the layouts of the following shops :
 1. Carpentry and pattern-making shop.
 2. Foundry shop.
 3. Fitting shop.
 4. Smithy shop.
 5. Machine shop.
 6. Welding shop.
 7. Sheet metal and Painting shop.
 8. Plumbing and masonry shops.
14. Give the list of equipment needed for the following shops :
 1. Carpentry and pattern-making shop.
 2. Foundry shop.
 3. Fitting shop.
 4. Smithy shop.
 5. Machine shop.
 6. Welding shop.
 7. Sheet metal and painting shop.
 8. Plumbing shop.
15. List separately the operations done in the shops of which the layouts are required in Q. No. 13.