CHAPTER XXVI

PLANT LOCATION

One of the early decisions that an entrepreneur has to make is the choice of a location for his place of business. Although there are several factors which influence his choice, yet the choice of the location for building a factory may have been made by mere chance. There are many successful businesses that have no apparent reason for their location other than the fact that it was convenient when the business was founded. If a man has a better product for which there is a demand, he can build up a satisfactory business through persistent and well-directed advertising and sales efforts regardless of location. Few customers care where a product is made if it serves the purposes better than anything else, and if the price is right. There are, however, operating advantages and disadvantages that may affect economical manufacture and distribution of the product. *The governing principle is that the location of a plant should be fixed in such a manner that people interested in its success can sell goods most profitably and manufacture them with the least expense.*

Factors in Locating Business

The fundamental factors which have to be considered in determining the location of a plant for profitable working are as follows :

Buying

1. Nearness to raw materials.
2. Accessibility to raw materials.

Manufacturing

1. Proximity to large adaptive labour.
2. Nearness to sources of power.
3. Ready accessibility to repair shops.
4. Nearness to good banking and credit facilities.
5. Adequate transport and communication facilities.
6. Ability to build and expand plant cheaply.
7. Government regulaton and subsidy.
8. Adequate fire fighting facilities.
9. State of organisation and development of learning.
10. Suitable soil, climate, and topography.

Association with Other Industries

1. Complementary industries.
2. Competing industries.
3. Momentum of an early start.

Selling

1. Nearness and accessibility to market.
2. Population.
3. Style movement.

BUYING

Nearness to Raw Materials. The cost of obtaining raw materials is an influence on location. The importance of nearness to raw materials varies greatly with the nature of the business. Two sub-divisions of this factor present themselves. One is the assurance of a constant and immediate supply, without dependence on transport or weather conditions. The other is the fact that the cost of transporting bulky raw materials a long distance may add so much to the cost of production as to make the business unprofitable. It is much better, for instance, to manufacture cement at the place where raw materials are than it would be to pay transport charges on them. The ideal location with reference to materials is the one where all factors combine to make the lowest possible raw materials cost per unit of completed product. The location of cotton textile in Bombay, jute in Calcutta, iron and steel in Jamshedpur, was influenced by this factor.

Accessibility to Raw Materials. The presence in abundance of any material is not sufficient in itself. It must also be easily accessible. If the region is inaccessible, it is unexploitable, for it is in effect bare of resources required to support life. The workers who have to work at getting the raw material should have supplies of food and water. There must also be present adequate transport facilities, fertile soil, and suitable climate.

MANUFACTURING

Availability of Labour. Labour supply means the number of skilled and unskilled persons who are available for the kinds of work to be done. Labour supply is perhaps the most important of all the factors, especially when skilled labour is required. This is demonstrated by the manufacturing centres such as Bombay, Jamshedpur, Madras, Kanpur, Nagpur and Ahmedabad where industrial labour is available.

Nearness to Source of Power. The sources of energy for turning the wheels of industry have had a very decisive influence in plant location and the development of industrial centres. The recent development of hydro-electric power with high tension lines to transport electric power to industrial areas has to some extent minimised the importance of power as a significant factor in plant location.

Ready Accessibility to Repair Shops. This factor is important mainly in the case of small-scale industries. Where orders are plentiful and a breakdown occurs at any point a firm loses business as well as prestige, if repairs are not carried out immediately and work completed

at the stipulated time. In a large firm, repairs may be carried out in the factory itself.

Nearness to Good Banking and Credit Facilities. Industry cannot exist and grow with funds to be invested in its development. The funds are obtained from banks and other financial institutions. A small concern must be near banks, etc., although in the case of a large firm, which commands wide and good credit, location is not so important. There is an economic geography of the supply of loanable capital, and of the activity of financial institutions, as there is of raw material or labour supply. The rate of interest would be lower in remote corners than in cities, but it is available in abundance in large centres.

Transport and Communication. Of the economic factors governing plant location transport costs are very important. It is necessary to obtain raw materials and market finished goods. In the choice of a site, attention must be given to the availability and frequency of rail, water, road, air transport services. The term transport implies the existence also of storage, handling and service facilities, and industries are attached to those localities where these are readily available at reasonable cost.

Adequate Fire Fighting Facilities. Fire may orignate from within or without. Internal fire can be controlled with fire fighting appliances, but it is difficult to control agencies causing fire from outside. A site with adequate fire fighting facilities is therefore desirable.

State of Organisation and Development of Learning. New industries, as well as the development and expansion of those already established, hinge on research and investigation to develop products and improve methods. Moreover, the profitable operation of industry is dependent on a constant supply of educated and trained men. To provide both of these, educational institutions and research agencies are needed. These will be found where industry is successful.

Ability to Build and Expand Plant Cheaply. A plant has to be built in such a way that the manufacturing processes are carried on with minimum expenditure of time and material. Also, there must be ample scope for additions or re-arrangement, so that they can be carried out without stoppage of work. Low cost land will be most desirable for putting up a factory.

Political Stability. Governments influence the development of industry by maintaining political stability, and by means of subsidies. Lack of political stability stand in the way of establishment of factories or drive away those already established, as has been happening in West Bengal.

Suitable Soil, Climate and Topography. Soil and climate have direct bearing upon the type of activity which will be undertaken by any area in its early development. Climate has a great influence on the industrial activity. A cool invigorating climate develops the best type of industrial worker. Inhabitants of very warm climates are less efficient as industrial workers. Topography also exercises an important influence on location. For instance, mountain barriers, plateaus and large rivers have a retarding influence on industrial development.

Association with other Industries. Some manufacturers select locations which are near complementary or subsidiary industries, i.e., those which produce materials and supplies used in connection with their own manufacturing processes. From the plant location standpoint, this tends to encourage the centralisation of industry. On the other hand, competition between establishments may in many cases act as encouragement for decentralization. Industries tend to thrive best in groups for the following reasons :

(a) A number of similar concerns in a locality can usually secure materials to better advantage than any one can do singly.

(b) Concentration of establishments, even of a like kind and direct competitions, improves the labour market, both for employer and employee, in many ways.

(c) A group of plants can jointly produce such a demand as will cause a variety of repair plants and supply houses and industrial service industries to establish themselves nearby, such as foundries, machine shops, tool makers, etc.

(d) In specialised centres banks learn the standing of the firms in the trade, and can more readily and safely discount the special line of commercial paper.

(e) A group of similar or related manufacturers established in one place serves to perfect their local market. The reputation of each firm supplements that of others, until the name of the town becomes almost a trade mark, and a firm enjoys prestige from the mere fact of location in the noted place.

(f) A large specialised manufacturing centre is able to afford various commercial service industries such as packers, insurers, forwarders, professional graders and appraisers, advertising agencies, public warehouses, etc.

The Momentum of an Early Start. As a rule, people are likely to feel confidence in an industry that is being started in a locality where similar ventures have been successful. A certain amount of inertia attaches itself to industry where it has once been successful in a given place. The momentum of a great centre is so strong that it prevents other localities from lightly entering the ranks against it.

SELLING

Nearness and Accessibility to Market. The advantages of market consideration need to be compared with the advantages of locating near raw materials. Nearness to customers is as important as nearness to raw material. A manufacturer can keep in touch with the pulses of his markets when he is located near them. Sometimes industrial centres offer peculiar advantages because buyers gravitate towards them.

Characteristics of People. All manufacturers exist to supply markets with goods which people will buy. The market which a community affords for consumption goods depends upon the population

its wealth and its habits of life. Consumption goods can be sold only when the thinking and living habits of the people are such they can be persuaded to include these products in their pattern of living.

Style Movement. People will not buy style goods from a market which they believe to be one receiving new ideas later than themselves. The law of style movement is from larger cities to smaller ones, and from neighbourhood of abundant wealth to that of less wealth.

FACTORY SITES

Country, City or Suburb. The relative advantages of the three exact situations may be considered. Country (i.e., village) offers cheap land and so works can be spread out. This reduces fire hazards and one-storey buildings can be used. The rates, rents and taxes are low. More devoted labour disposed to teamwork is available. More healthy workers and hence more efficient. But highly skilled workers are hard to get in a village, and repair shops are not readily available.

The city offers abundant skilled labour, although the wage bill will be higher. City location is the best for women workers. It is near to the market, and a small plant will usually do well in a city, as auxiliary services are near at hand. But the land costs, rents, rates and taxes are high. Generally, village location is good for large plants and the city for small ones. In recent years, however, the tendency has been to locate plants in the suburbs of large cities. A suburb, being midway between the city and the rural area, offers advantages of both.

Decentralisation and Dispersal. The significance of location factors is not static but changing. Not only has human invention lessened the significance of some factors, but also by natural trends of events some have ceased to operate. For example, the introduction into textile mills of automatic humidifying equipment has lessened considerably the importance of climate in location problems of this industry.

Not infrequently, the original advantages sought are no longer of great significance in the achievement of profitable manufacturing operations. In recent years, large industries have tended to decentralise their activities, by placing subsidiary plants at a considerable distance from the parent plant. Or, in order to bring about lateral integration, subsidiary plants manufacturing complete products of allied nature are located at a distance to avoid congestion. This dispersal of plants has marked advantages in relation to material supplies, labour, and distribution of product. Dispersal of industries has become a universal phenomenon. In India a "Balanced Regional Development" has been advocated and followed.

Balanced Regional Development. With a view to bringing about regional balance in industrial location, as suggested by the Fiscal Commission, the Planning Commission has followed in the successive Five-Year Plans the balanced regional development policy. The Second Plan had the following programmes :

(a) provision of facilities such as power, water supply, transport and communications, training institutions, etc., in areas which were lagging behind industrially;

(b) programmes for the expansion of village and small industries;

(c) in the location of new enterprises, whether public or private, consideration was given to the need for developing a balanced economy in different parts of the country.

While, in the selection of sites for basic capital and producer goods industries, proximity to raw materials and other economic considerations have naturally been important. in the wide range of consumer goods and processing industries regional pattern of development has been fostered. Typical examples are the establishment of the textile units in Rajasthan, Orissa, Assam and Punjab; sugar factories and distilleries in Andhra, Tamil Nadu, Mysore, Maharashtra; steel-rolling mills in Assam, Kerala, Madhya Pradesh and North Bihar. In the policy followed in licensing of new units, the same considerations have been kept in view.

The development of new processes and new uses of raw materials has assisted in the spread of industry. Thus, with the use of bagasse it is possible to set up paper factories in the sugarcane growing areas. Village and small industries are spread all over the country and various forms of assistance provided by the State are made available. Industrial estates have been set up in all States, and increasingly they are to be located in the smaller towns and rural areas.

With development on a scale larger and more comprehensive than in the earlier Plans, the Third Plan provided extensive opportunity for the development of different parts of the country. Greater dispersal of industries was continued and is being followed in the Fourth Plan too. In granting licences to industrial projects in the private sector, the claims of under-developed regions are kept in view and locations in such areas are suggested to prospective industrialists. As a result of this policy, the four important industries—cotton textile, sugar, cement and paper—have reached almost all the important regions and their concentration has been checked.

Optimum Plant Location. We began with our discussion of the problem of plant location with the governing principle that the location which results in the lowest unit cost in producing and distributing the product to the consumer would be the exact optimum location. As we have seen in previous sections, this optimum depends upon the interplay of various costs, such as freight charges on raw materials, cost of fuel, power and water, cost of plant site, cost of building, labour costs, and freight charges on finished products. The entrepreneur will have to work out the cost analysis on the basis of these costs to keep the cost of production as the lowest.

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CHAPTER XXVII

FACTORY PLANNING

The planner's task is more satisfying when he has the job of planning a new factory or workshop at the outset than when he has to improve, as best he can, an already established "system". But it demands a great deal of thought and skill. Some of the most important factors are as follows

TYPE OF FACTORY BUILDING

Having selected a suitable site, the next problem is to make the most advantageous use of it, and, in particular, to choose the right type and size of building for the intended form of industry.

Building Structure. The structure of the building will depend upon a number of factors. The first factor in the choice of a building is its suitability to the nature, purposes and requirements of the business. The *unit stresses* to which the various floors will be subjected will determine the thickness of the walls, the cross-sections of the girders and pillars, and the style of construction. As a rule, heavy manufacturing calls for heavy construction; light manufacturing does not. The width of a building and the height of its ceiling are dimensions which must be determined with reference to each other. Unless there is roof lighting, the greater the width of a building, the higher the windows must be to give adequate illumination in the centre of the rooms. The length of a manufacturing building is influenced by fire hazards.

Single-storey or multi-storey Building. The single-storey building is generally more suitable for large constructional work and for housing heavy machinery, such as foundries, erection shops for engines, bridges, etc. The multi-storey building is usually favoured for lighter work.

Advantages of one-storey building. The advantages of a single-storey building over a multi-storey building are as follows :

1. One-storey building can be constructed for a lower cost per square foot than multi-storey structures meeting similar specifications. The multi-storey building requires expensive foundations and loses considerable areas to lifts, stairwells, and structural columns.

2. Flexibility of layout is generally greatest in a one-storey rectangular plant which provides a large production area that can be sub-divided to meet one's needs.

3. One-storey buildings admit of indefinite extension in any direction.

4. Erection time often can be minimised by selecting a one-storey structure.

5. Natural lighting can be made available throughout the plant.

whereas only on the top floor of a multi-storey building can equivalent use be made of natural light. However, one should realize that natural light is at best unreliable, and skylights require much maintenance.

6. Similarly, ventilation is much better in single-storey buildings; and such buildings are more easily heated and cooled.

7. In a one-storey building, the foundations for machinery are cheaper, and the machinery being set directly on the ground causes no vibration in the building.

8. One-storey buildings are exposed much less to the hazards of fire than multi-storey structures.

9. For most activities a one-storey plant lends itself to efficient supervision and operation.

On the other hand, the multi-storey building is not without its advantages for some enterprises.

Some of the *advantages of multi-storey* buildings are :

1. A multi-storey building facilitates the use of overhead storage and gravity feeds of materials.

2. For a specific amount of floor area, less land is required for a multi-storey building than for a one-storey structure.

3. Upper floors, being removed from dusty ground levels, may be considerably cleaner than lower floors and, of course, an entire one-storey structure.

Building design and fire prevention. Building should be so designed as to prevent fire. Selection of proper equipment and materials, as well as proper design of the plant and processes can prevent fire. Satisfactory detection and alarm systems should be provided, as also fire extinguishers, fire pails and hoses. Fire can be prevented from spreading through the installation of fire walls and doors, sprinklers and hose system . Adequate entrances for firemen and exits for employees should be provided, and the employees should be educated and trained in the need for fire prevention and emergency procedures.

Lighting. Good lighting is conducive to efficient working and high morale, reduction of eye strain and accident rates. The essentials of an adequate system of illumination are : (1) sufficient amount; (2) proper distribution and diffusion; (3) absence of glare; (4) freedom from fluctuations; and (5) freedom from injurious invisible radiations.

As the sense most employed in locating things is sight, scientific use of colours also will contribute to greater comfort and visibility. Colours seem to influence people's attitudes, green being cooling and relaxing, deep colours being oppressive, and red and yellow being warming and stimulating.

Ventilation. Many industrial studies have shown that the combined effect of high temperatures and humidity can reduce mental alertness and increase physical fatigue. Humidity must be maintained at proper level as provided by the rules under the Factories Act. Ideal heating and ventilation consists in distributing, without injurious drafts, an adequate supply of air of the proper temperature and degree of

humidity, and free from dust and noxious gases. As a hot, humid and still atmosphere is bad, the air of the working place should be reasonably cool, moderately dry, and kept in motion.

Noise Control. Noise adversely affects one's co-ordination and ability to concentrate and causes one to be fatigued and irritable. Noise reduction methods must be adopted, such as the use of noise-absorbing materials or accoustics. Special attention must be paid to the accoustical treatment of vibration.

Machines and Equipment. Long before the new factory is nearing completion careful thought must be given to the ordering of new plant and equipment. Before purchase, the following points ought to be considered. As a first step, it will be necessary to decide which types of machine will be most suitable. The choice lies between (i) *general purpose* machines, which are not too highly specialised as regards the kind of work they are capable of undertaking, nor too restricted in respect of sizes; (ii) special-purpose machines, designed for a specific job, or for producing or dealing with a particular article or size of article.

Price must obviously be considered and the quotations of several suppliers ought to be compared, but other factors are equally, if not more important. Technical considerations, such as performance efficacy, simplicity of operation, reliability, modern design and techniques and uniformity of type and size, should be taken into account.

Plant and Equipment Maintenance. Effective maintenance of a plant and its equipment is pre-requisite to efficient plant operation as well as uninterrupted production. Plant buildings deteriorate because of (1) the effects of the weather—sun, rain, cold, heat, wind—and (2) wear and tear resulting from general use, vibration, fumes, etc. While deterioration cannot be stopped, it can be greatly retarded by maintenance.

Machines and equipment likewise are subject to wear and tear from use. They require maintenance, if only cleaning and lubrication, to keep them in good running order. Many require adjustment; some require more repairs than others. All maintenance work has to be scheduled to ensure regular attention. Inspection will anticipate and prevent many a breakdown. This is often called *Preventive Maintenance*. Preventive maintenance is more efficient than *Remedial Maintenance*. In other words, inspection before a breakdown enables the maintenance department to plan repairs and schedule them when the plant is inactive at nights or on Sundays, thus preventing a breakdown and disturbance of operations.

The *Maintenance Department* carries on the following activities: make emergency repairs; make routine repairs; inspect machines and equipment to detect misuse or needed repairs; make scheduled repairs and renewals in such a manner as to make maximum use of the available manpower and minimize the disturbance to operations. It keeps records of the various machines and equipment as a guide to the proper use and selection of new equipment for a given purpose. It supervises construction work carried out by an outside agency, if any. It arranges for the

sharpening of production tools, and maintains cost records that are used by the accounting department and by management.

Equipment Replacement. The establishment of a sound programme for the replacement of equipment is essential for any concern interested in staying in business permanently. Any discussion of equipment replacement is concerned with depreciation and obsolescence. *Depreciation* is an annual charge reflecting the decline in value of an asset due to such causes as wear and tear, the action of the elements, obsolescence, and inadequacy and are influenced also by tax factors, the capital structure of the enterprise, and changing price levels. *Obsolescence* is the depreciation of existing equipment due to the invention of new and better processes or equipment. It is thus a measure in rupees and paise of the declining productivity and efficiency in relation to those of more recently developed equipment. A proper replacement policy must consider all cost factors for both present and proposed equipment. Whichever equipment will result in the lower over-all cost of manufacture generally should be purchased.

PLANT LAYOUT

Maximum productivity from plant buildings and equipment can be attained only where these facilities are so integrated as to provide a smooth flow of materials, parts, and products. Smooth flow is the result of a good plant layout.

Management can attain the desired objectives through an efficient plant layout. The objectives to be attained are as follows :

1. Economics in material and product handling.
2. Lower cost of useful areas.
3. Minimising of production delays.
4. Better production control and supervision.
5. Avoidance of bottlenecks.
6. Avoidance of unnecessary and costly changes once a layout is made.
7. Improvements in production processes and methods.
8. Provision of a layout that permits meeting of competitive costs; and
9. Incorporation of safety into the physical plant as part of the layout and organisation.

Plant layout ideally involves the allocation of space and the arrangement of equipmnt in such a way that over-all operating costs are minimised. A completed layout project represents the master plan for physically integrating the factors of production which are required on the premises. Poor layouts result in high materials handling costs, high labour requirements and costs, idle machinery, large in-process inventories, and excessive space requirements, to mention only a few of the consequent inefficiencies.

Definition. *Plant layout* is the technique of locating machines

processes and plant services, within the factory so as to achieve the greatest possible output of high quality at the lowest possible total cost of manufacturing. It aims at discovering an optimum plan by which each operation is performed at the point of greatest convenience, without permitting the point of 'greatest convenience' for one process to conflict with that appropriate to others.

Factors that influence the plant layout. The type of industry, the quantity of production, the type of product, the type of operations and the type of worker must be considered in determining the final plant layout. The industry may be either a continuous or an assembly type. A *continuous industry* is one in which all the material is received at one point, from which successive operations turn it into a finished product, as in yarn spinning and paper and pottery manufacture. *An assembly industry* is one in which the finished product can be produced only after various components have been made and then brought together for final operations, such as the manufacture of shoes and automobiles. In factory layout this difference is significant. Some continuous industries are *synthetic*; that is, the product is obtained by bringing together various ingredients which are combined in the manufacturing process, as paper manufacture or yarn spinning or paint making. Paint, for example, is a combination of white lead, oils and other pigments. Other continuous industries are *analytical*; that is, the product is obtained by successive processes that separate the final product from the mass of original material. All refining industries, such as oil and by-products of coke, are of this nature. Assembly industries are also of two types : (1) those in which the *components are similar* and go through similar operations, as, for instance, in clothing industry; and (2) those in which the *components are dissimilar* and go through unlike processes, as for instance, the automobile industry.

For continuous process industry, the layout decided upon should be such that successive processes will be carried through in shops that adjoin one another in the sequence the processes follow. Then the article being produced will pass in a continuous line from the first to the second, the second to the third and so on until the finished product is ready. For example, a synthetic process will usually be laid out to resemble a river. Just as a river's tributaries merge together as the river continues down-stream, so also do the various materials and parts of a synthetic process merge into the completed assembly as one follows the layout path through the plant. An analytic-process layout, on the other hand, takes the form of a tree as it starts out with a single material or substance (the trunk) and spreads out into a variety of resultant materials (the branches, leaves, and fruit). Where the product is constructed with parts assembled from the several shops in which they have been made, the erection of the complete machine takes place in an assembly department centrally situated in relation to the contributory workshop.

The type of worker is a fundamental consideration, where many decisions concerning factory layout must be changed because of the

requirements of these employees. The type of product, that is, whether the product is heavy or light, large or small, liquid or solid, is another fundamental consideration in plant layout. Although the manufacture of spark plugs and locomotives both involve assembly work, layout problems differ materially. Layout problems in any plant in which the product can be flowed, either by gravity or by pumps, from one operation to another, as in flour or sugar manufacture, differ from those in which work in process must be handled by hand, conveyor, or truck in moving from one operation to the next.

The type of manufacture also markedly influences plant layout. The industry that manufactures in large quantities a relatively few standardised products may be laid out on the so-called *straightline* or *product* basis as well as *process* or *functional* basis, whereas the *job-lot-manufacturing* type of industry, in which many unlike operations of non-standard products are required, is almost of necessity largely on the *functional* basis.

Types of layout. Layout may be by product (line) or it may be by process (functional). It may also be by *stationary material*. A *product layout* is one in which each machine is located according to the operation sequence required in producing one product of a group of related products. Layout by products, therefore, implies that operations are performed in a sequence and that the product is assembled or worked upon as needed. For example, a firm having two products, A and B, might set up two different production lines. Line A, which produces product A, might have an oven, a lathe, a milling machine, and a surface grinder, in that order. Line B might start with a forge and have a heat-treating station, an inspection station, and two lathes following. The lathe for the A line could be in the north-east corner of the building, and those for the B line might be located diametrically opposite. The plan given above illustrates the product layout.

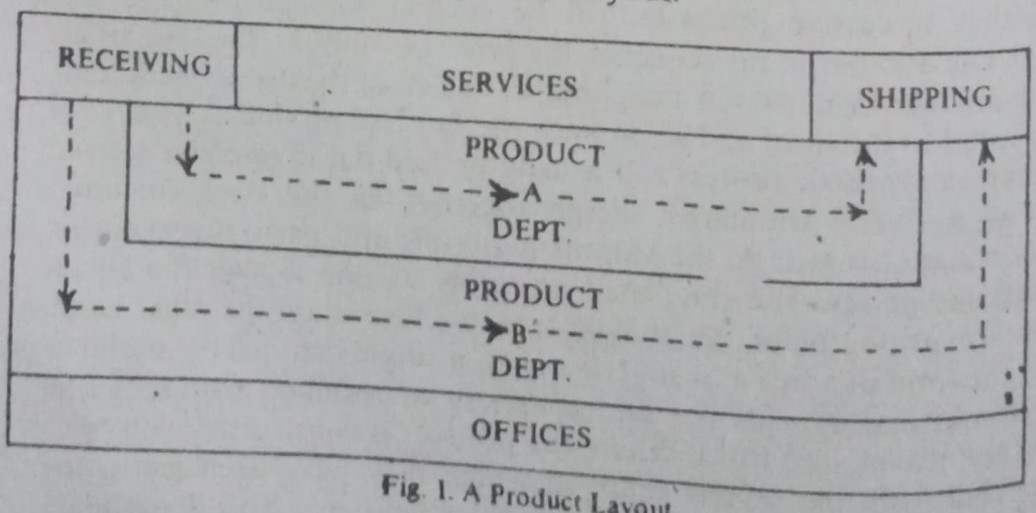

Fig. 1. A Product Layout.

Direct-line layout is applicable either to a single floor of the factory or to the building as a whole. The central idea behind layout of product is a continuous flow of materials in process towards the finished-product stage.

The *advantages* of layout by product are as follows :

1. It facilitates the use of materials-handling devices and conservation of floor space.
2. Internal transportation and back-hauling is minimised.
3. When properly adjusted, bottlenecks are eliminated.
4. Production control is facilitated, because once a product is started along the line, it is difficult for it to be side-tracked.
5. There is a considerable shortening of the manufacturing time from the first operation to the finished product.
6. There is a reduction of the work-in-process inventory.
7. There is also some reduction of the finished-product inventory, since production control is more complete and promises to customers from production are more reliable.

Some of the *disadvantages* of the product layout are : (1) Decreased flexibility; (2) increased investment in equipment; (3) frequently greater difficulty in expanding production beyond the capacities of the lines in layout by product than in functional layout; (4) greater difficulty in securing specialization in supervision.

Layout by process or *functional layout* is one in which machines are grouped according to their types, resulting in a lathe department, a milling-machine department, and an inspection department, among others. The functional layout is characterised by the assembling of

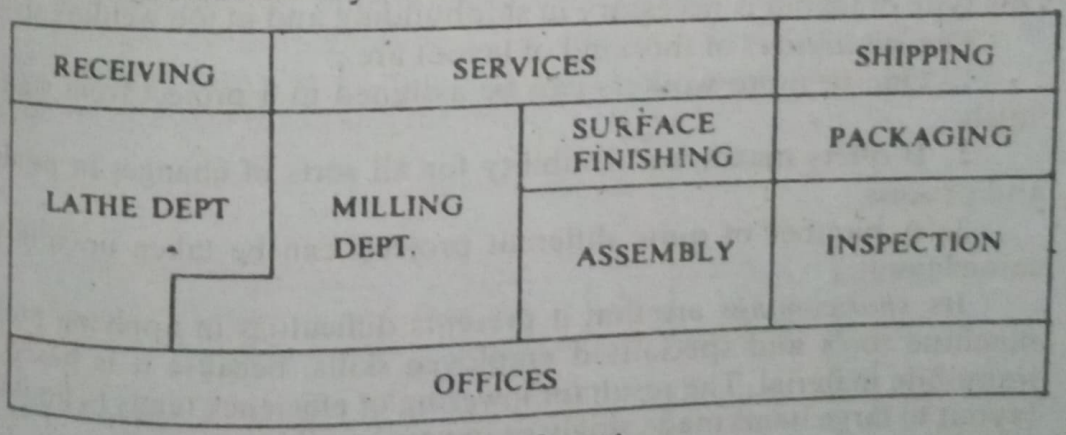

Fig. 2. Process Layout.

similar operations in one place; for instance, all drilling is performed in a drill-press department, and all electric welding is done in the electric-welding department. This type of layout carries out the functional idea of Frederick W. Taylor. It is useful for job-lot manufacturing or the manufacture of non-standardised products.

The *advantages* of layout by process are as follows :—

1. Greater flexibility, in that changes in operations and the sequence of operations seldom involve a change in layout.
2. Easier adjustment to changes in volume of production, especially when it is necessary to add equipment.
3. More ready adaptation to special needs arising from certain types of equipment, such as the protection of workers against exhausting fumes or the flashing of light in electric welding.

4. More complete utilisation of equipment, and hence a lower investment in equipment.

5. Better utilisation of the skill of the workers by following the principle of specialisation.

6. More effective use of the specialised abilities of supervisors.

The functional layout is strong where layout by product is weak, and weak where product layout is strong. It is seldom that an industrial enterprise of any magnitude is laid solely on either a product or a functional basis. Many organisations, however, are predominantly of one type or the other.

The *disadvantages* of functional layout are essentially the same as the advantages of the product type of layout. The *disadvantages* are : (1) Greater difficulty in automatic material handling and need for more floor space for the same volume of production; (2) excessive back-hauling of materials in process; (3) more time required to make the same product; (4) greater difficulty in production control; (5) excessive work-in-process inventory; (6) tendency to increase the finished-stock inventory if the same service to customers is given as is accomplished under product layout.

Layout by Stationary Material. This type of layout is designed primarily for manufacture of large parts and assemblies. Here the men and equipment are moved to the material, which remains in one place. This type of layout is necessary in shipbuilding and in job welding shops.

The *advantages* of this kind of layout are :

1. One or more workers can be assigned to a project from start to finish.

2. It offers maximum flexibility for all sorts of changes in product and process.

3. A number of quite different projects can be taken up with the same layout.

Its *shortcomings* are that it presents difficulties in applying proper machine tools and specialised employee skills, because it is based on immobile material. The resultant lowering of efficiency tends to limit this layout to large items made singly or in very small lots.

Sequences and Smooth Flow. In planning a layout care must be taken in allotting space to various workshops or departments, so that pressure here or there may not soon force these to burst their bounds. What space to allow to different departments will be decided on previous experience of the working of the business or, if that is not available, a careful estimate will have to be prepared for each room in relation to the equipment and operations it will have to house. Following this the relation of production centres with reference to the sequences of processes and the movements of materials in the course of manufacture must be determined. The aim must be to secure a smooth flow of work throughout the undertaking, avoiding both congestion because of bottlenecks, and the necessity of work-in-progress to retrace ground already covered. A crowded shop prevents employees from making rapid